Epistemic Boundedness, Poverty of the Stimulus, Amodal Completion, and *wugs*

Charles Reiss, Concordia

Outline

Empirical base

English regular plural

SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

Empirical base

English regular plural

SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

Speech sounds are sets of features

- [s] in *mats* is −Voiced (w/o vocal fold vibration) and +Coronal, ...

Empirical base

English regular plural

SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

Speech sounds are sets of features

- [s] in *mats* is −Voiced (w/o vocal fold vibration) and +Coronal, ...
- [z] in *heads* is +Voiced (w/ vocal fold vibration) and +Coronal, ...

Empirical base

English regular plural

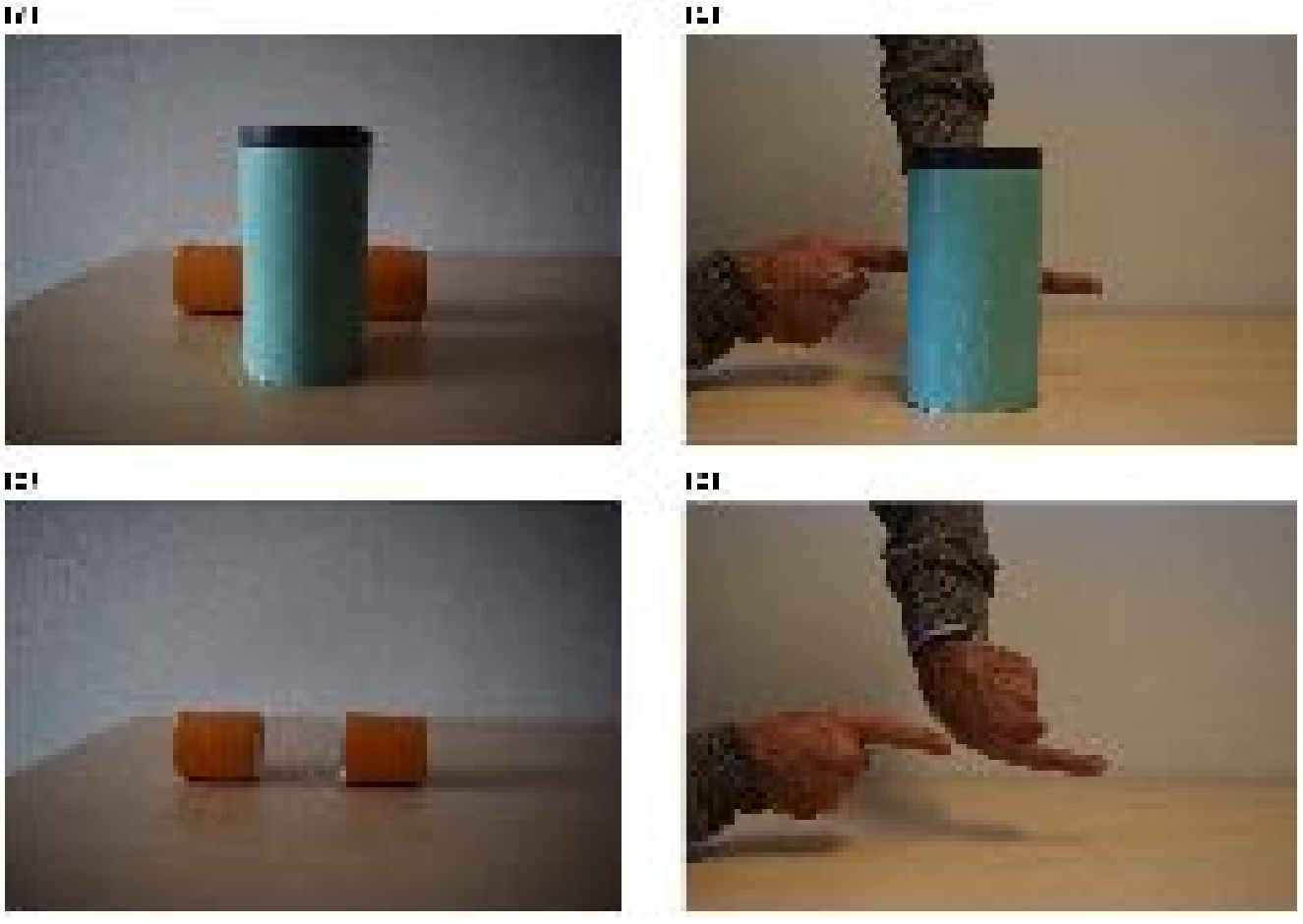
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

Speech sounds are sets of features

- [s] in *mats* is −Voiced (w/o vocal fold vibration) and +Coronal, ...
- [z] in *heads* is +Voiced (w/ vocal fold vibration) and +Coronal, ...
- [ɨz] in *bushes* has an extra vowel

Amodal completion

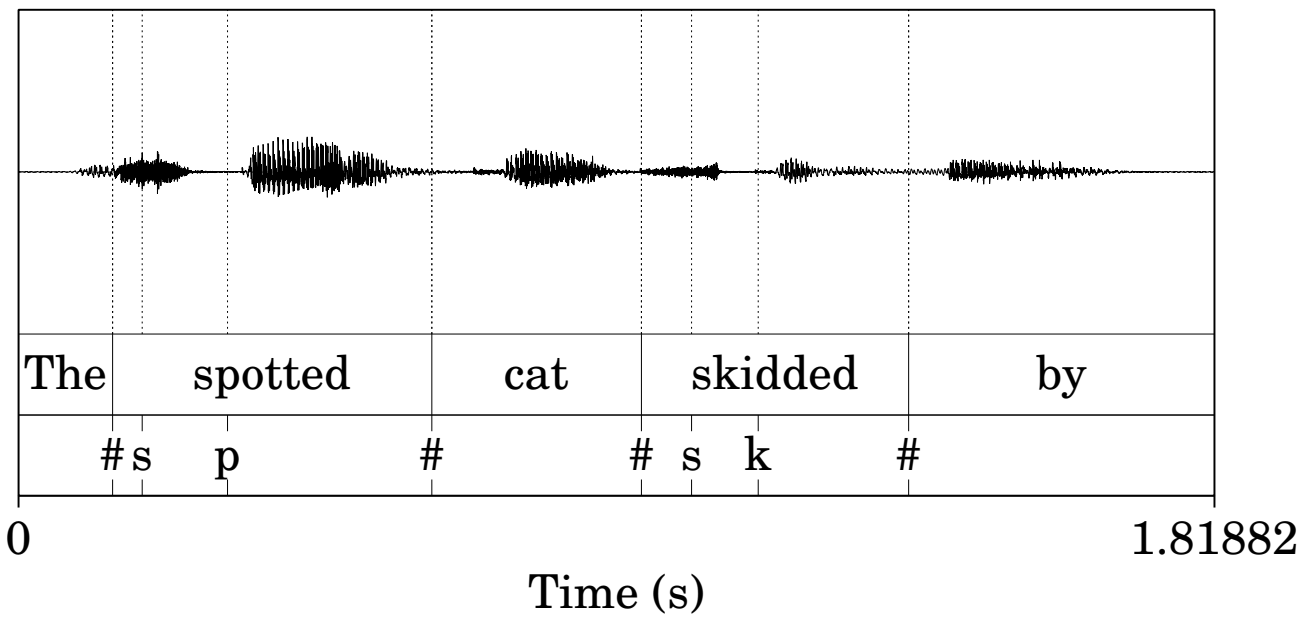
Amodal completion



Poverty of the Stimulus (PoS)

Howard Lasnik (2000:3)

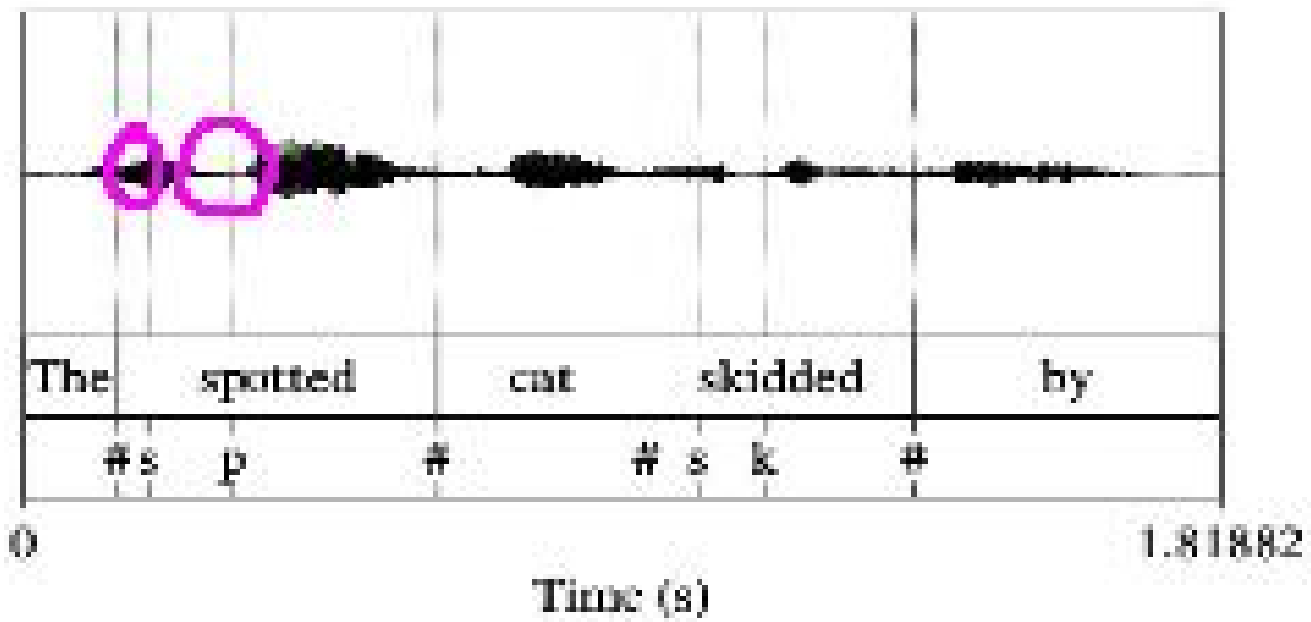
The big step is going from "noise" to "word".



Poverty of the Stimulus (PoS)

Howard Lasnik (2000:3)

The big step is going from "noise" to "word".



Lasnik et al. (2000, p. 3)

Poverty of the stimulus exists right at the word level

The list of behaviors of which knowledge of language purportedly consists has to rely on notions like "utterance" and "word." But what is a word? What is an utterance? These notions are already quite abstract. Even more abstract is the notion "sentence." Chomsky has been and continues to be criticized for positing such abstract notions as transformations and structures, but the big leap is what everyone takes for granted. It's widely assumed that the big step is going from sentence to transformation, but this in fact isn't a significant leap. The big step is going from "noise" to "word".

Not radical enough

Poverty of the stimulus is everywhere

- Phonological patterns
  - alternations, intonation, stress
- Syllables
- Segments
- Features
- Rules
  - my focus

Not radical enough

Poverty of the stimulus is everywhere

- Phonological patterns
  - alternations, intonation, stress
- Syllables
- Segments
- Features
- Rules
  - my focus

PoS: The input underdetermines the acquired knowledge state w/o significant priors: UG exists.

Rationalism and empiricism

- Rationalism favors view in which scientists come up with ideas, make inferences and deductions, and only then appeal to observation to confirm or refute predictions.
- Empiricism would favor a view in which generalizations, theories, and laws arise out of a large body of observation.

Rationalism and empiricism

- Rationalism favors view in which scientists come up with ideas, make inferences and deductions, and only then appeal to observation to confirm or refute predictions.
- Empiricism would favor a view in which generalizations, theories, and laws arise out of a large body of observation.

In cog sci, also replace 'scientist' with 'kids'

Take home

The Argument from the *Poverty of the Stimulus* is as relevant in *phonology* as in other domains.

Take home

The Argument from the *Poverty of the Stimulus* is as relevant in *phonology* as in other domains.

Two part strategy

- A "brief, cavalier and dogmatic" (Tolman 1948) attack on empiricist perspective towards representations

Take home

The Argument from the *Poverty of the Stimulus* is as relevant in *phonology* as in other domains.

Two part strategy

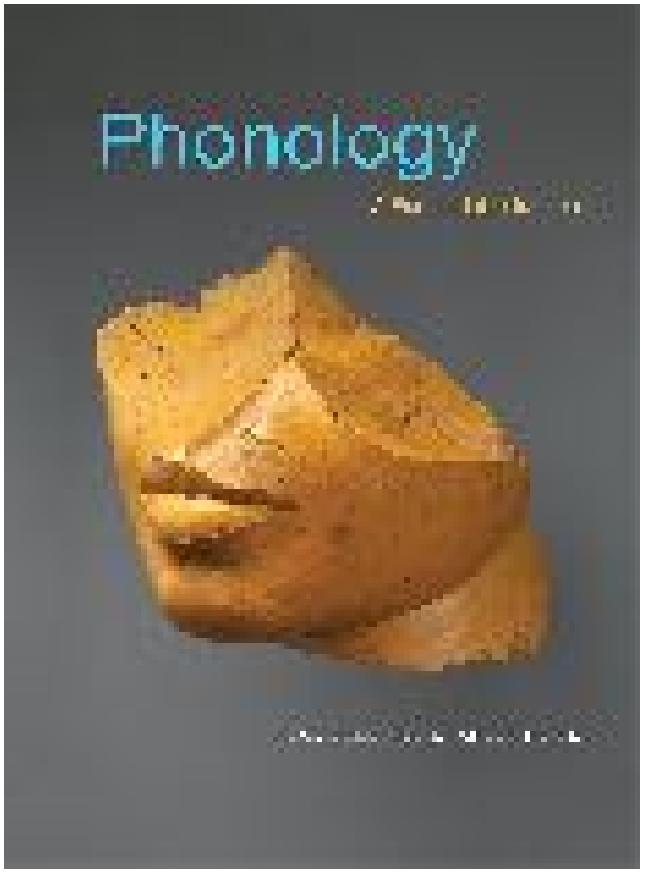
- A "brief, cavalier and dogmatic" (Tolman 1948) attack on empiricist perspective towards representations
- Demonstration that rule ordering in English supports rationalist perspective and APoS

Need *some* phonological theory—let's use mine today

Derivations

- Rules are functions
- Built from basic set theoretic operations
- A phonology is a composition of rules
- 'Logical Phonology'

Bale & Reiss (2018)



- CRUCIAL: There is no point in bickering about HOW acquisition happens without a sense of WHAT is acquired.

- CRUCIAL: There is no point in bickering about HOW acquisition happens without a sense of WHAT is acquired.
  - Psychologists, take note!

- CRUCIAL: There is no point in bickering about HOW acquisition happens without a sense of WHAT is acquired.
  - Psychologists, take note!
- For today, we'll use my WHAT.

- CRUCIAL: There is no point in bickering about HOW acquisition happens without a sense of WHAT is acquired.
  - Psychologists, take note!
- For today, we'll use my WHAT.
- See Pinker (1984/96), *Language Learnability and Language Development*

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties
- $C = \{\textit{chocolate ice cream, vanilla yogurt, vanilla ice cream}\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties
- $C = \{\textit{chocolate ice cream, vanilla yogurt, vanilla ice cream}\}$
  - *yogurt* is not a member of this set

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties
- $C = \{\textit{chocolate ice cream, vanilla yogurt, vanilla ice cream}\}$
  - *yogurt* is not a member of this set
- $D = \{A, B, 5\}$

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties
- $C = \{\textit{chocolate ice cream, vanilla yogurt, vanilla ice cream}\}$
  - *yogurt* is not a member of this set
- $D = \{A, B, 5\}$
  - a set can be a member of a set

Set theory refresher 1

Sets are abstract collections of members/elements

- $A = \{x, y, z\}$
  - sets can be finite—A has three members
- $F = \{x, y\}$
  - F is a subset of A: $F \subseteq A$
  - A is a superset of F: $A \supseteq F$
- $\mathbb{E} = \{2,4,6,...\}$
  - sets can be infinite, like the set of even positive integers
- $B = \{\text{Venus, Mars, love, gravity, the pizza I had for lunch}\}$
  - members need not share properties
- $C = \{\textit{chocolate ice cream, vanilla yogurt, vanilla ice cream}\}$
  - *yogurt* is not a member of this set
- $D = \{A, B, 5\}$
  - a set can be a member of a set
  - x and Mars are not members of D

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Intensional characterization of a set

- $\mathcal{S}$ = The set of Seymour's favorite letters

Extensional characterization of a set

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Intensional characterization of a set

- $\mathcal{S}$ = The set of Seymour's favorite letters
- $S = \{s : s \text{ is one of Seymour's favorite letters}\}$

Extensional characterization of a set

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Intensional characterization of a set

- $\mathcal{S}$ = The set of Seymour's favorite letters
- $S = \{s : s \text{ is one of Seymour's favorite letters}\}$

Extensional characterization of a set

- $\mathcal{S}$ = {A,B,C} last year

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Intensional characterization of a set

- $\mathcal{S}$ = The set of Seymour's favorite letters
- $S = \{s : s \text{ is one of Seymour's favorite letters}\}$

Extensional characterization of a set

- $\mathcal{S}$ = {A,B,C} last year

  Circumstances change

Set theory refresher 2

Intersection

$\{a,b,c,d\} \cap \{a,c,f,g\} = \{a,c\}$

Intensional characterization of a set

- $\mathcal{S}$ = The set of Seymour's favorite letters
- $S = \{s : s \text{ is one of Seymour's favorite letters}\}$

Extensional characterization of a set

- $\mathcal{S}$ = {A,B,C} last year

  Circumstances change
- $\mathcal{S}$ = {X,Y,Z} this year

You know all this if you play cards

- Color: R/B

You know all this if you play cards

- Color: R/B
  - each card is either red or black

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣
  - each card has a suit: heart, diamond, spade or club

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣
  - each card has a suit: heart, diamond, spade or club
- Rank: F/N

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣
  - each card has a suit: heart, diamond, spade or club
- Rank: F/N
  - each card is either a face card or a number card (Ace is N)

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣
  - each card has a suit: heart, diamond, spade or club
- Rank: F/N
  - each card is either a face card or a number card (Ace is N)

You know all this if you play cards

- Color: R/B
  - each card is either red or black
- Suit: ♡/♢/♠/♣
  - each card has a suit: heart, diamond, spade or club
- Rank: F/N
  - each card is either a face card or a number card (Ace is N)

5♡ and what else?

$$\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\}$$

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)
  - $\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\} \cap \left\{ \begin{array}{c} \text{Color:B} \\ \text{Suit:}\spadesuit \\ \text{Rank:N} \end{array} \right\} = \{ \text{ Rank:N } \}$

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)
  - $\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\} \cap \left\{ \begin{array}{c} \text{Color:B} \\ \text{Suit:}\spadesuit \\ \text{Rank:N} \end{array} \right\} = \left\{ \text{ Rank:N } \right\}$
- ⇝ all the cards that are supersets of {Rank:N}.

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)
  - $\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\} \cap \left\{ \begin{array}{c} \text{Color:B} \\ \text{Suit:}\spadesuit \\ \text{Rank:N} \end{array} \right\} = \left\{ \text{ Rank:N } \right\}$
- $\rightsquigarrow$ all the cards that are supersets of {Rank:N}.
- For fun, a set of cards is a *set of sets* of features

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)
  - $\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\} \cap \left\{ \begin{array}{c} \text{Color:B} \\ \text{Suit:}\spadesuit \\ \text{Rank:N} \end{array} \right\} = \left\{ \text{ Rank:N } \right\}$
- $\rightsquigarrow$ all the cards that are supersets of {Rank:N}.
- For fun, a set of cards is a *set of sets* of features
  - $X = \{x : x \supseteq \{\text{Rank:N}\}\}$

Treat each card as a set of features.

- The **natural class** defined by 5♡ and 9♠ is found by taking the **intersection** of the features they contain
  - 5♡ ∩ 9♠ (each card is a SET!)
  - $\left\{ \begin{array}{c} \text{Color:R} \\ \text{Suit:}\heartsuit \\ \text{Rank:N} \end{array} \right\} \cap \left\{ \begin{array}{c} \text{Color:B} \\ \text{Suit:}\spadesuit \\ \text{Rank:N} \end{array} \right\} = \left\{ \text{ Rank:N } \right\}$
- $\rightsquigarrow$ all the cards that are supersets of {Rank:N}.
- For fun, a set of cards is a *set of sets* of features
  - $X = \{x : x \supseteq \{\text{Rank:N}\}\}$
  - "all the number cards"

Suppose card rules are like phonology rules

- Rules must be ordered
- Rule **environments** and **targets** must be natural classes of cards

Here are two apparent generalizations:

a. Rule Q: The red cards *except for* diamond face cards are put in a box **if they are found on the floor**.

Here are two apparent generalizations:

a. Rule Q: The red cards *except for* diamond face cards are put in a box **if they are found on the floor**.
   - (Diamond number cards and all hearts)

Here are two apparent generalizations:

a. Rule Q: The red cards *except for* diamond face cards are put in a box **if they are found on the floor**.
   - (Diamond number cards and all hearts)

b. Rule R: The diamond face cards are put on the table **if they are found on the floor.**

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K$\diamondsuit$ satisfies both conditions

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K$\diamondsuit$ satisfies both conditions
- Rule ordering

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K$\diamondsuit$ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K$\diamondsuit$ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards
  - Second, apply Q = to (all) red cards

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K♢ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards
  - Second, apply Q = to (all) red cards
    - Circumstances have changed on the floor!

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K♢ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards
  - Second, apply Q = to (all) red cards
    - Circumstances have changed on the floor!
- We'll use this later for English plural

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K♢ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards
  - Second, apply Q = to (all) red cards
    - Circumstances have changed on the floor!
- We'll use this later for English plural
- If you are philosophically inclined, why is this important?

Can the rule targets be defined using the superset notation?

a. Target of Q = red cards *except for* diamond face cards

b. Target of R = diamond face cards

- How do we solve the problem?
  - K♢ satisfies both conditions
- Rule ordering
  - First, apply R = to diamond face cards
  - Second, apply Q = to (all) red cards
    - Circumstances have changed on the floor!
- We'll use this later for English plural
- If you are philosophically inclined, why is this important?
  - rationalism vs. empiricism:

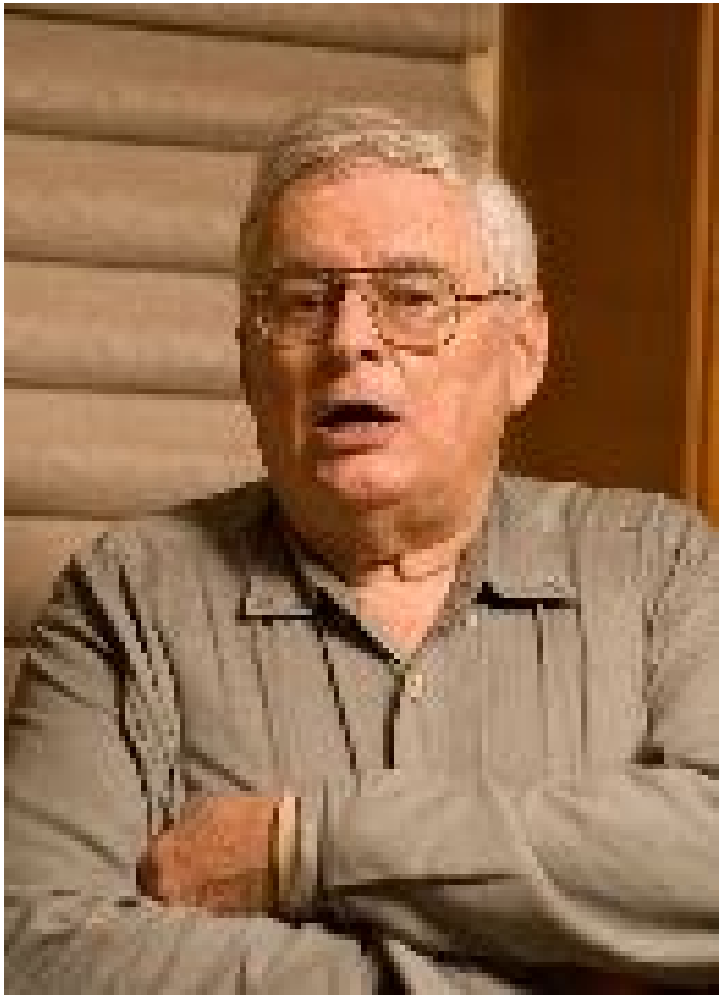
Outline

Philosophical implications: Epistemic boundedness

Fodor (1983), *Modularity of Mind* p.2

There are "constraints on the kinds of problems that human beings can solve, hence on the kinds of things that we can know."

Jerry Fodor on epistemic boundedness (1980)



The reasonable assumption ...is that human beings have an ethology, just as other species do; that the morphology of our cognitive capacities reflects our specific ...modes of adaptation. Of course, we are in some respects badly situated to elucidate its structure ...*From in here* it looks as though we're fit to think whatever thoughts there are to think. ...It *would*, of course, precisely because we *are* in here. But there is surely good reason to suppose that this is hubris bred of an epistemological illusion. No doubt spiders think that webs exhaust the options.

Examples?

Unthinkable thoughts

- mysteries vs. puzzles

Examples?

Unthinkable thoughts

- mysteries vs. puzzles
- free will, consciousness

Daniel Dennett making a mistake

In other moods, both Chomsky and Fodor have hailed the capacity of the human brain to parse, and hence presumably understand, the official infinity of grammatical sentences of a natural language. If we can understand all the sentences, can't we understand the sentences that best express the solutions to the problems of free will or consciousness?

Daniel Dennett making a mistake

> *In other moods, both Chomsky and Fodor have hailed the capacity of the human brain to parse, and hence presumably understand, the official infinity of grammatical sentences of a natural language. If we can understand all the sentences, can't we understand the sentences that best express the solutions to the problems of free will or consciousness?*

What's wrong with this?

Daniel Dennett making a mistake

> *In other moods, both Chomsky and Fodor have hailed the capacity of the human brain to parse, and hence presumably understand, the official infinity of grammatical sentences of a natural language. If we can understand all the sentences, can't we understand the sentences that best express the solutions to the problems of free will or consciousness?*

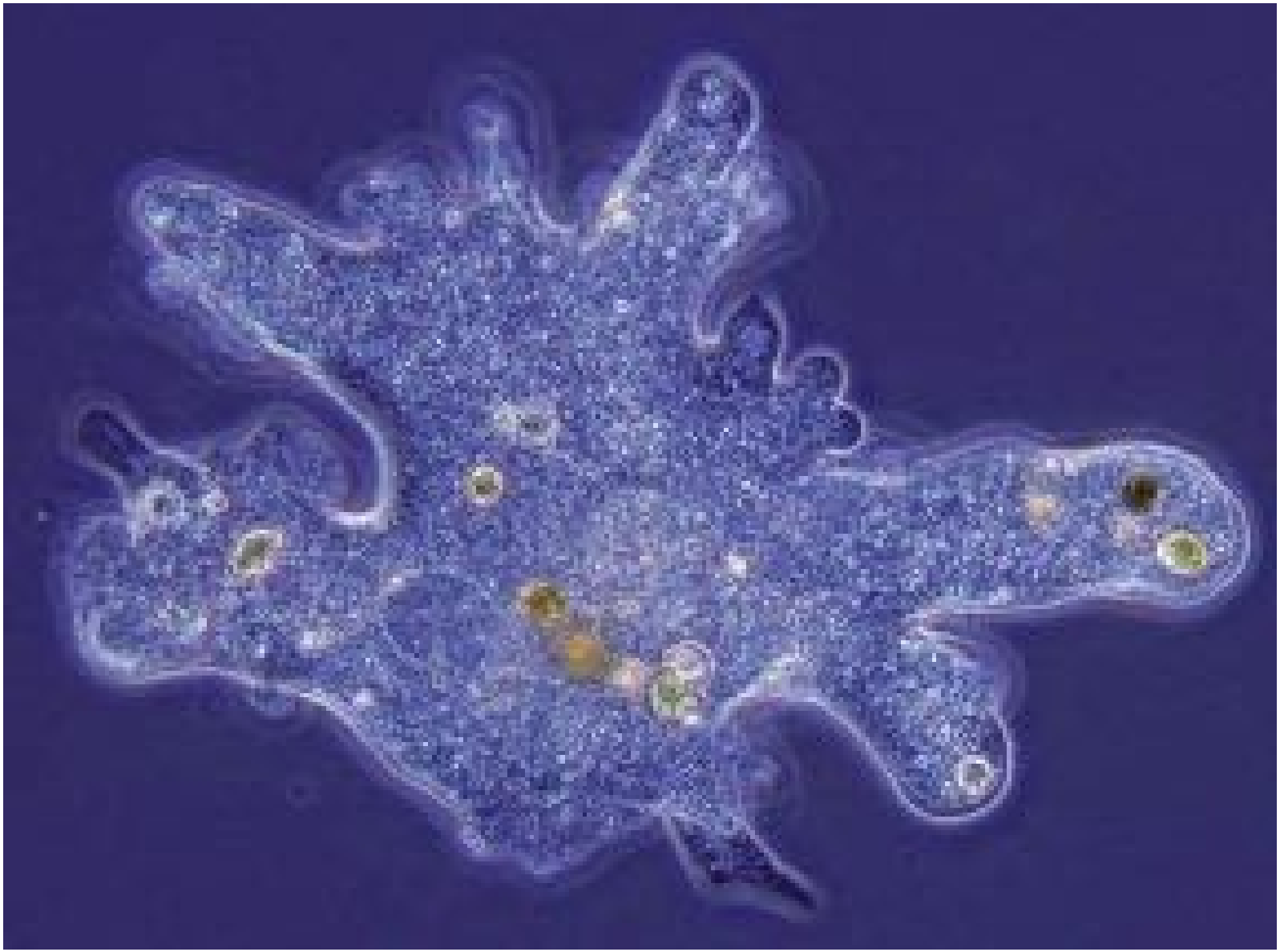
What's wrong with this? 'Infinity' is not 'everything'

Chomsky channels Popeye

Chomsky version of epistemic boundedness

You are not a mental amoeboid

Consider again the question whether cognitive functions are both diverse and determined in considerable detail by a rich innate endowment. If the answer is positive, for some organism, that organism is fortunate indeed. It can then live in a rich and complex world of understanding shared with others similarly endowed, extending far beyond limited and varying experience. ...



Epistemic boundedness ≈ Scope and limits

...Were it not for this endowment, individuals would grow into mental amoeboids, unlike one another, each merely reflecting the limited and impoverished environment in which he or she develops, lacking entirely the finely articulated and refined cognitive organs that make possible the rich and creative mental life that is characteristic of all individuals not seriously impaired by individual or social pathology—though once again we must bear in mind that the very same intrinsic factors that permit these achievements also impose severe limits on the states that can be attained; to put it differently, that there is an inseparable connection between the **scope** *and* **limits** *of human knowledge.*

Card game UG (see, e.g., Isac and Reiss, 2013)

Mars vs. Venus

- If UG_M gives a Martian just $\pm$RED, then (what *we* call) $\heartsuit$ and $\diamondsuit$ form a natural class, but Martians can't distinguish between them

Card game UG (see, e.g., Isac and Reiss, 2013)

Mars vs. Venus

- If UG_M gives a Martian just $\pm$RED, then (what *we* call) ♡ and ♢ form a natural class, but Martians can't distinguish between them
- If UG_V gives a Venusian just ♡, ♢, ♣, ♠ (but no colors), then Venusians can distinguish ♡ from ♢ but they can't group them together to the exclusion of the black suits (like *we* can)

Outline

What is *UG* about?

Sets of languages

Attested?

What is *UG* about?

Sets of languages

Attested?

- Reflects accidents of history, graduate school funding, etc.

What is *UG* about?

Sets of languages

Attested?

- Reflects accidents of history, graduate school funding, etc.
- 'English', 'Cree', 'French'

What is *UG* about?

Sets of languages

Attested $\subset$ Attestable? $\subset$ Statable

- What factors determine attestability in principle?

What is *UG* about?

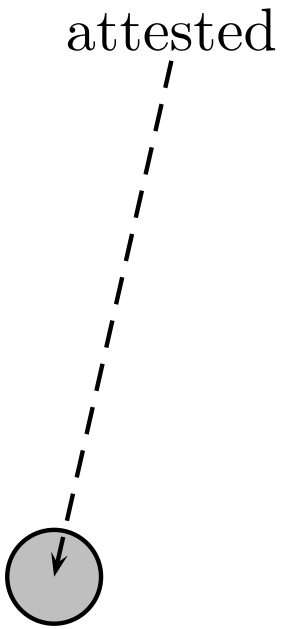
Sets of languages

Attested $\subset$ Attestable? $\subset$ Statable

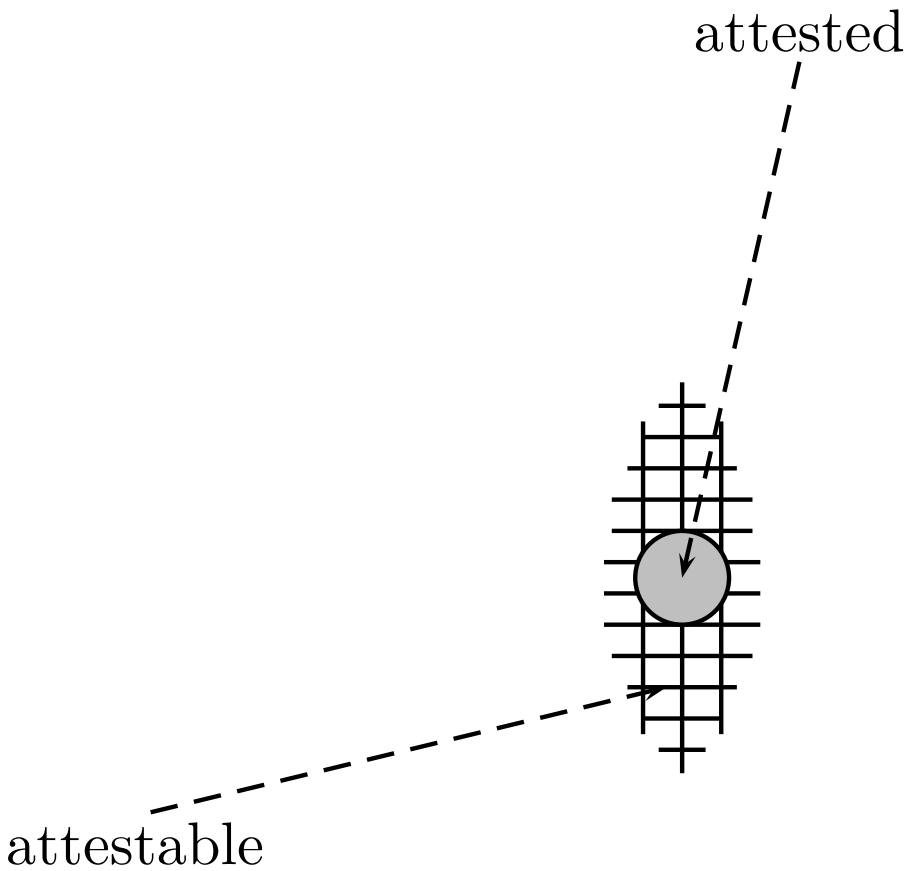
- What factors determine attestability in principle?
- English in 200 years, Joe's Japanese

What is UG about?

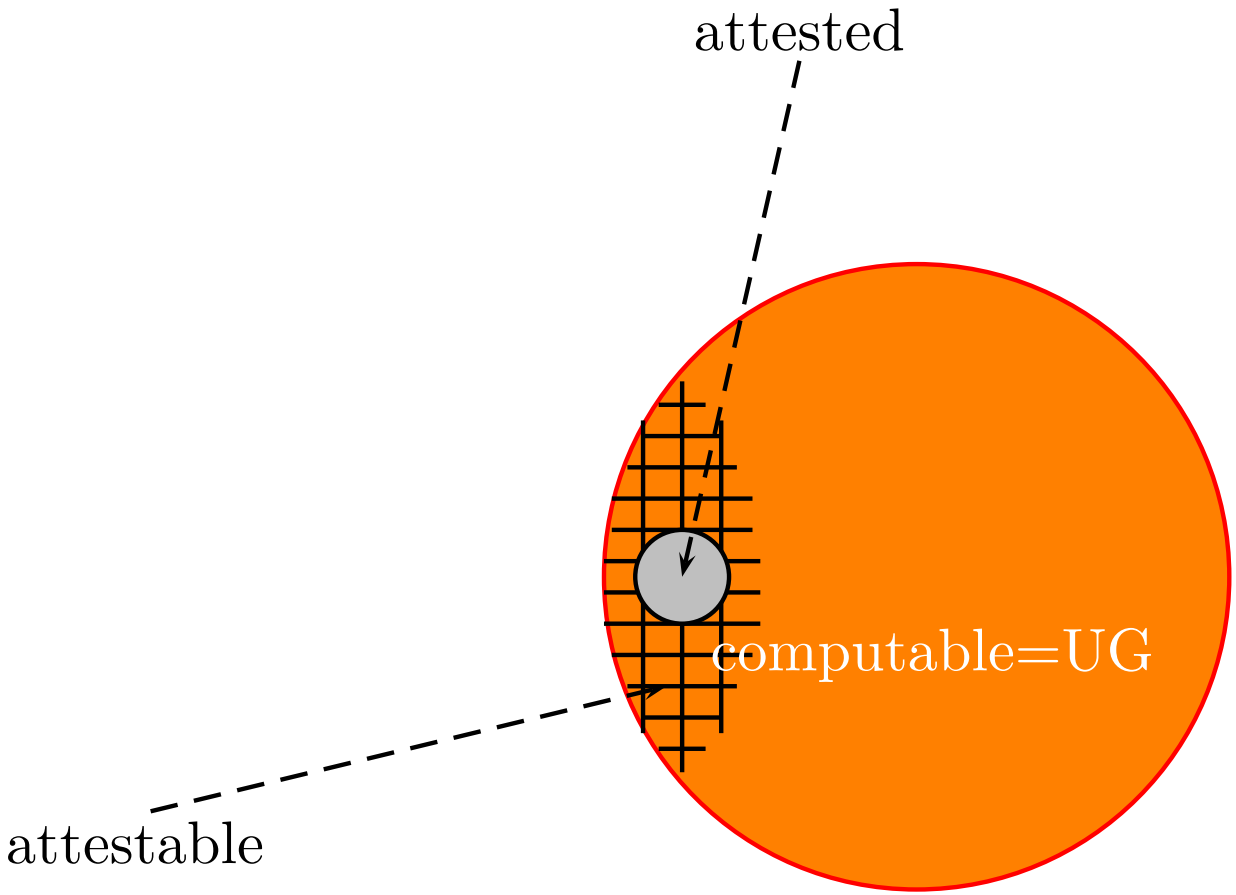
What is UG about? Attested?



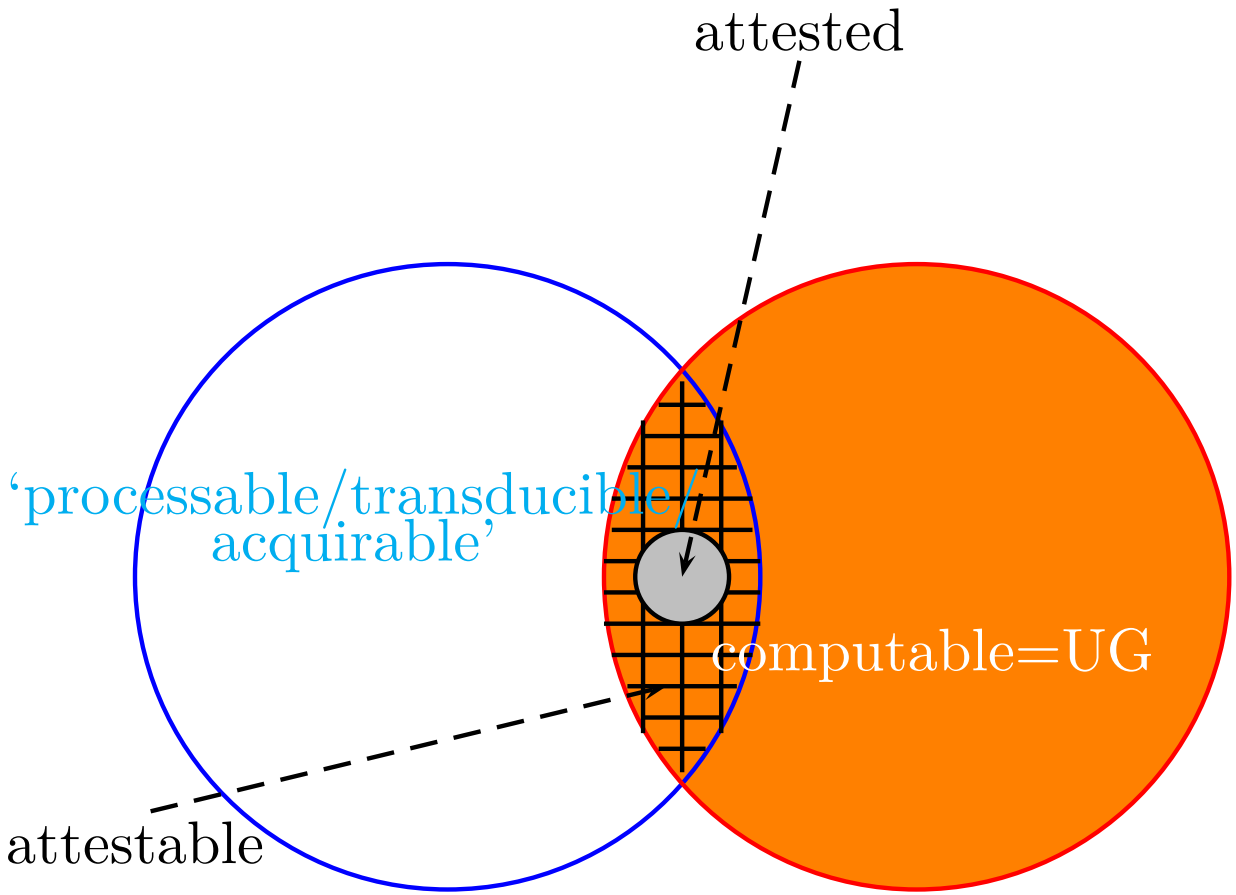
What is UG about? Attested, attestable



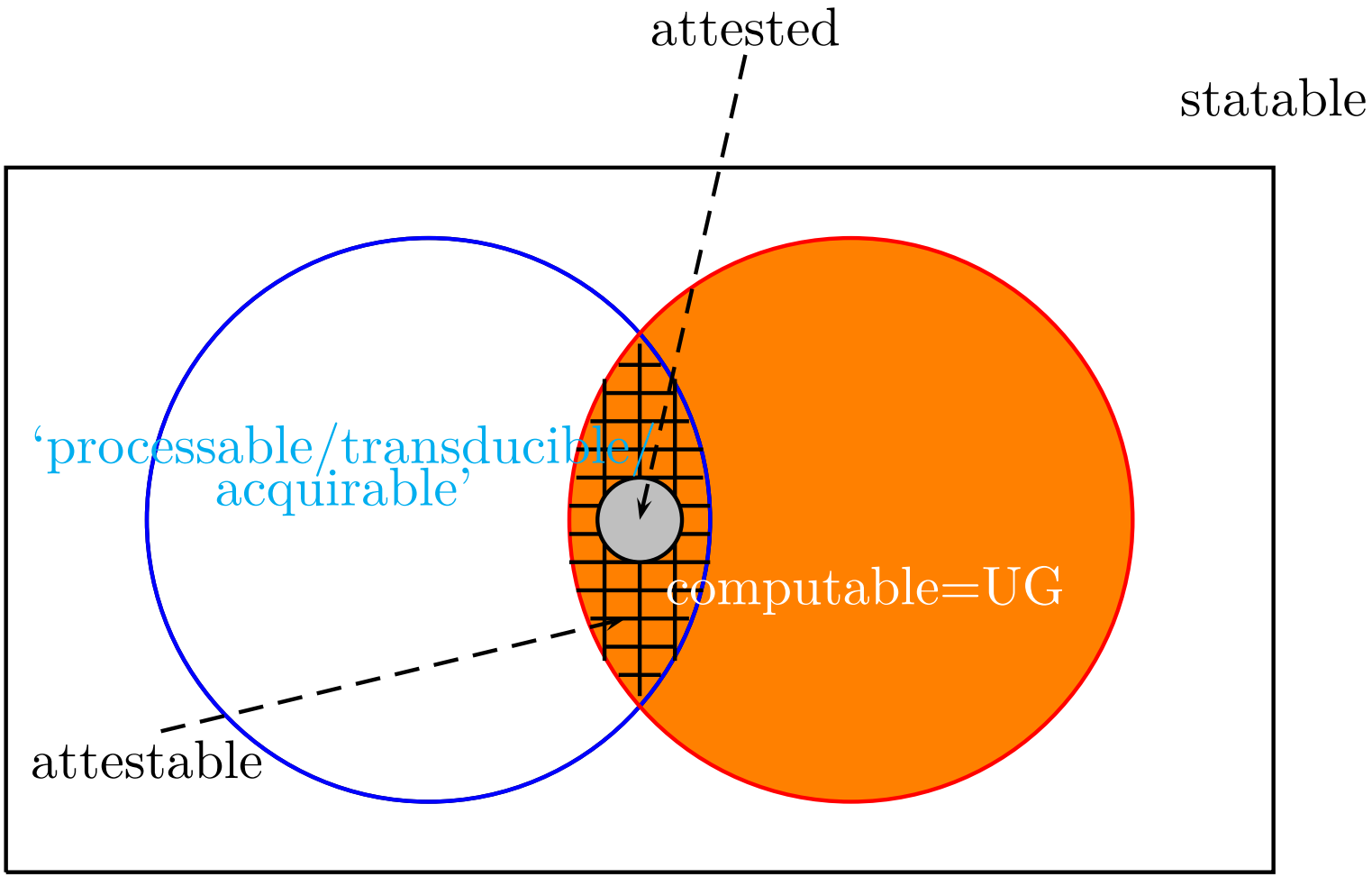
What is UG about? Attested, attestable, computable



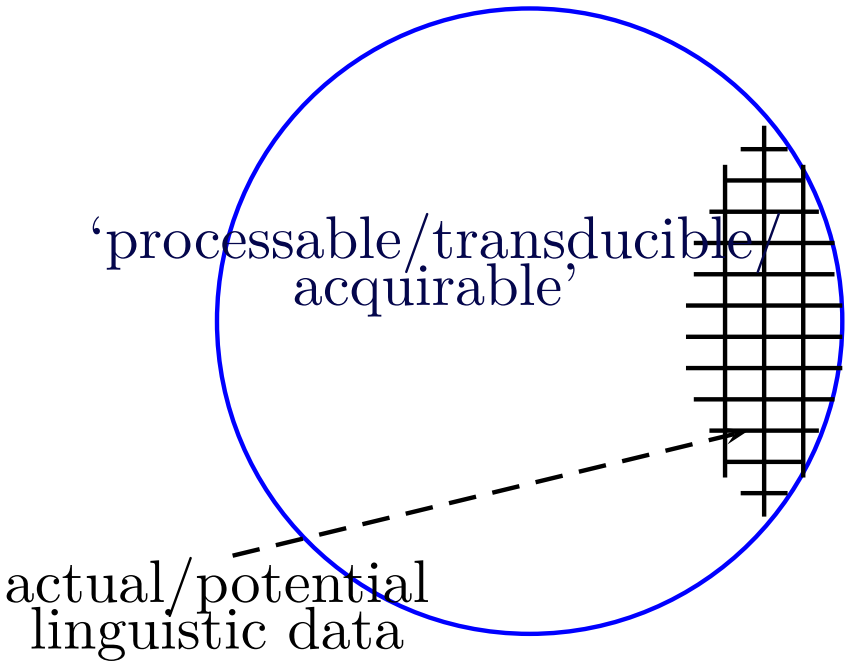
Attested, attestable, computable, X-able



...and statable

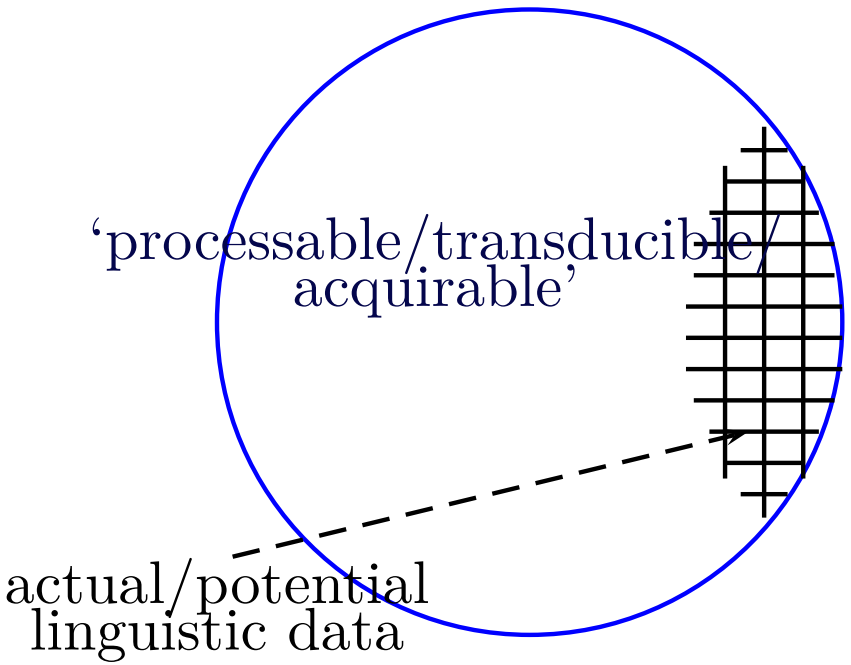


X-able stuff


‘processable/transducible/
acquirable’
actual/potential
linguistic data

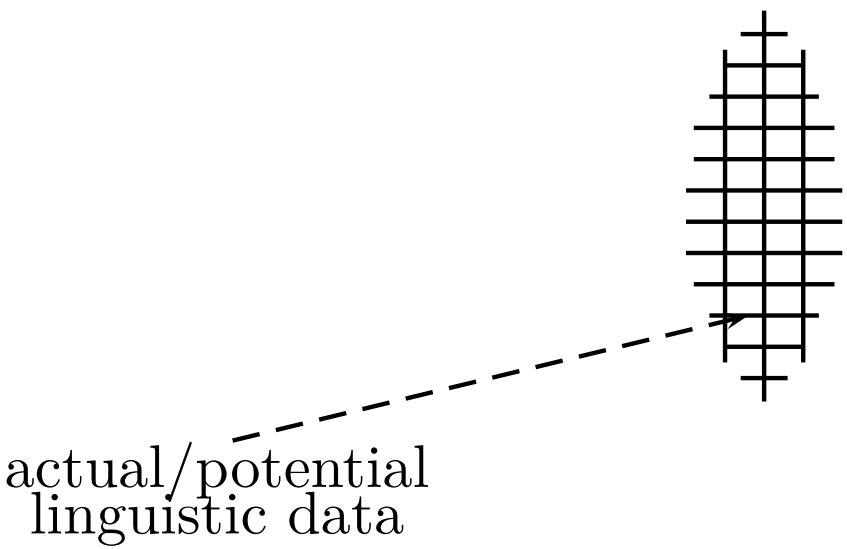
X-able stuff

Important and interesting, but not grammar



Attestable is *emergent*

We don't want a single model of "attestable", since its explanation results from the interaction of several simple(r) models



UG is the theory of one of those components.

We have failed to be convincing. Can we make it more palatable?

An analogy

A grammar : A set of sentences ::
A theory of UG : A set of languages

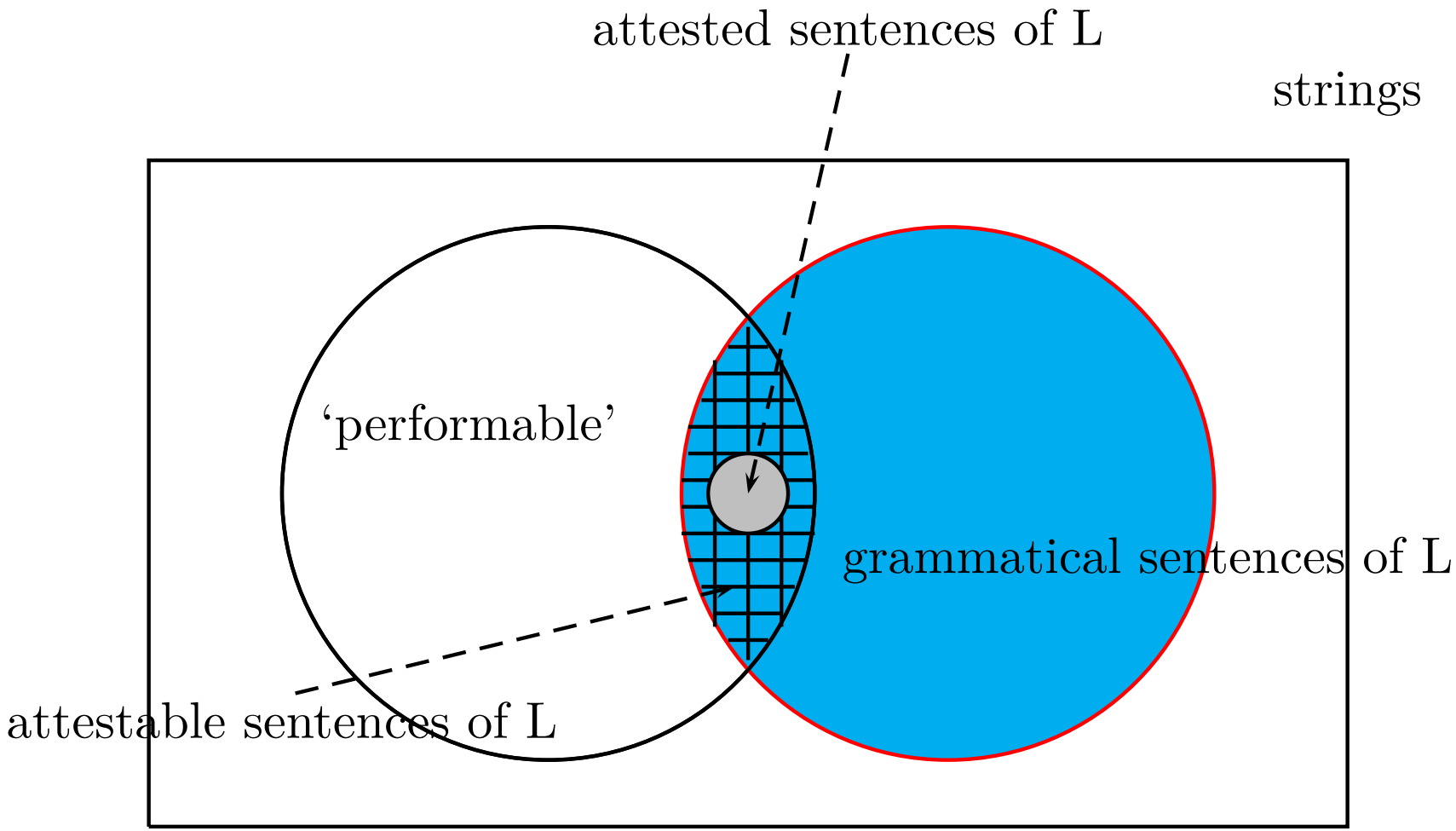
- A grammar generates ALL AND ONLY grammatical sentences

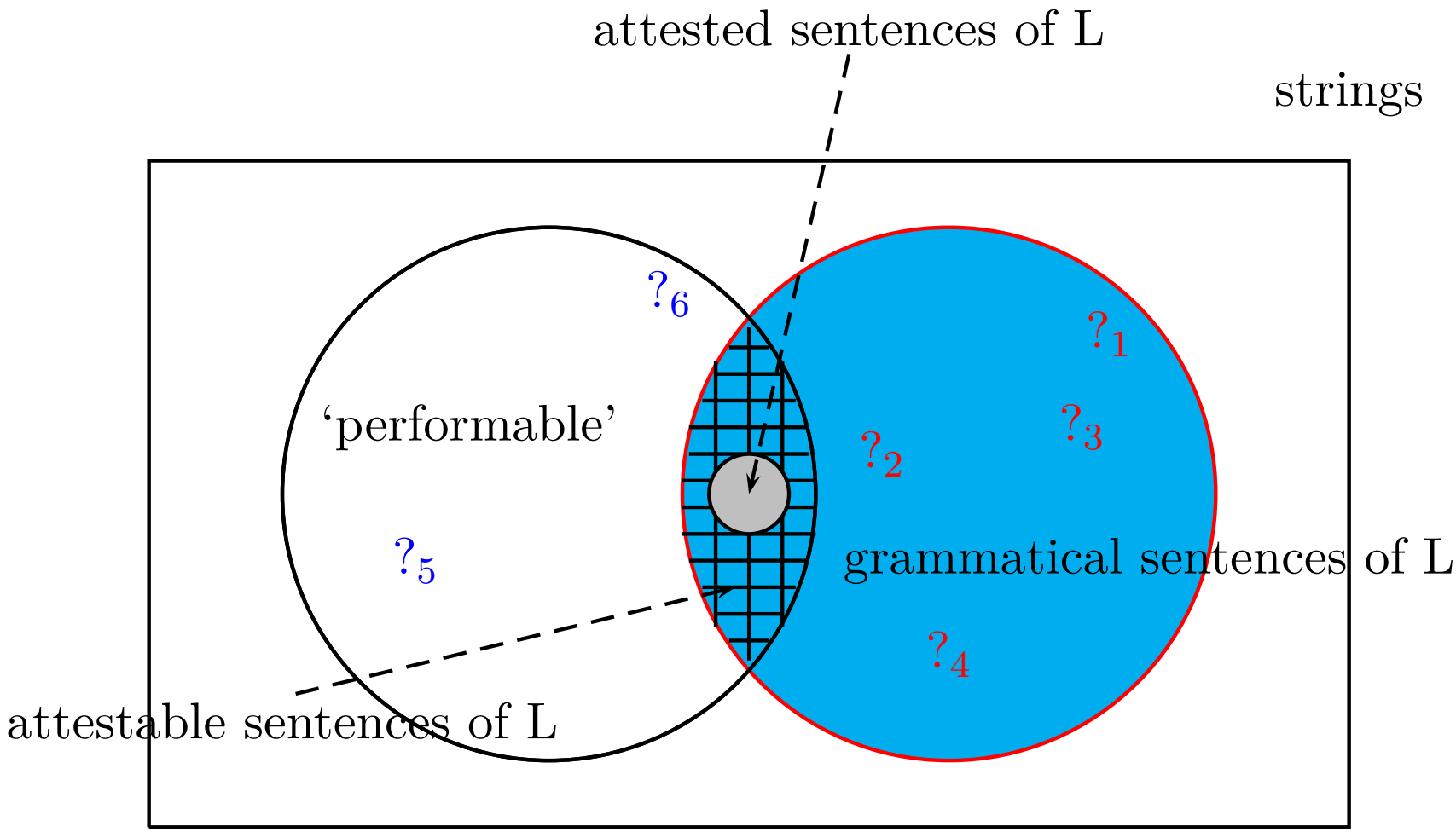
An analogy

A grammar : A set of sentences ::
A theory of UG : A set of languages

- A grammar generates ALL AND ONLY grammatical sentences
- UG models the set of ALL AND ONLY 'possible' languages

Strings and a Grammar L




attested sentences of L
strings
?6
?1
‘performable’
?3
?2
?5
grammatical sentences of L
?4
attestable sentences of L

Grammatical but unperformable

$?_1$: *The cat the dog the mouse bit chased purred.*

Grammatical but unperformable

?$_1$: *The cat the dog the mouse bit chased purred.*

?$_2$: *John saw the boy* ...[995 words] ...*yesterday.*

Grammatical but unperformable

$?_1$: *The cat the dog the mouse bit chased purred.*

$?_2$: *John saw the boy* ...[995 words] ...*yesterday.*

$?_3$: *It never happens that nobody is not unhappy.*

Grammatical but unperformable

$?_1$: *The cat the dog the mouse bit chased purred.*

$?_2$: *John saw the boy* ...[995 words] ...*yesterday.*

$?_3$: *It never happens that nobody is not unhappy.*

$?_4$: 'I quite agree with you,' said the Duchess; 'and the moral of that is—"Be what you would seem to be"—or if you'd like it put more simply—"Never imagine yourself not to be otherwise than what it might appear to others that what you were or might have been was not otherwise than what you had been would have appeared to them to be otherwise." ' [*Alice in Wonderland*]

Performable but ungrammatical

$?_5$: **Me like you.*

$?_6$: **John is allowed running here* (Unless you are Canadian)

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

1. Edge:RRR * * * *)

   Insert a R parenthesis to the R of the R-most *

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

2. Edge:RLR * * *) *

   Insert a R parenthesis to the L of the R-most *

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

3. Edge:RRL *) * * *

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

4. ?Edge:RLL)* * * *

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

5. Edge:LLL (* * * *
6. Edge:LRL *(* * *
7. Edge:LLR * * * (*

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

8. ?Edge:LRR * * * *(

Unacquirable, but computable

Modeling stress with Halle-Idsardi Edge-marking rules:

Three binary parameters yield eight rules:

4. ?Edge:RLL)* * * *

8. ?Edge:LRR * * * *(

RRR, RRL, RLR, ?RLL, LLL, LLR, LRL, ?LRR:
?=unacquirable

Seduction of substance

Don't be seduced into doing this:

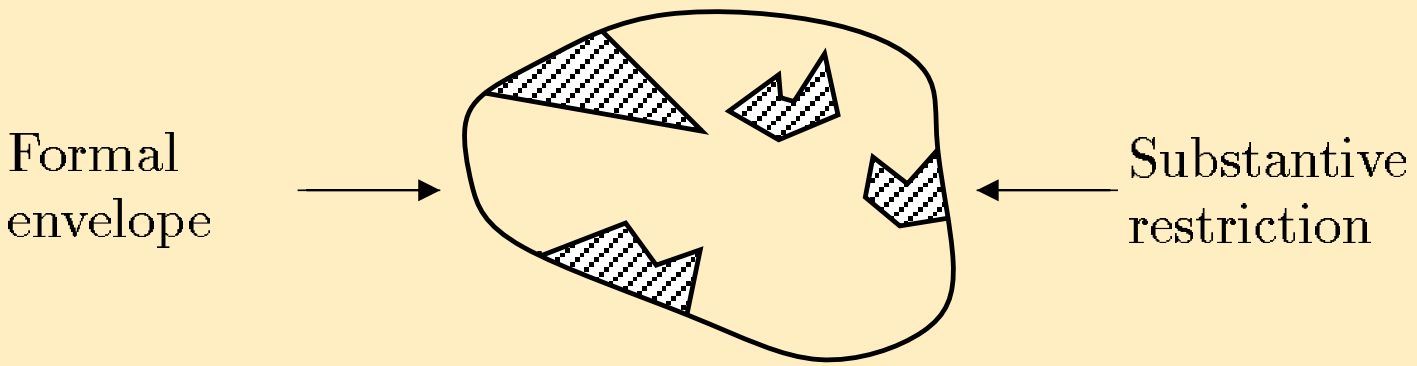
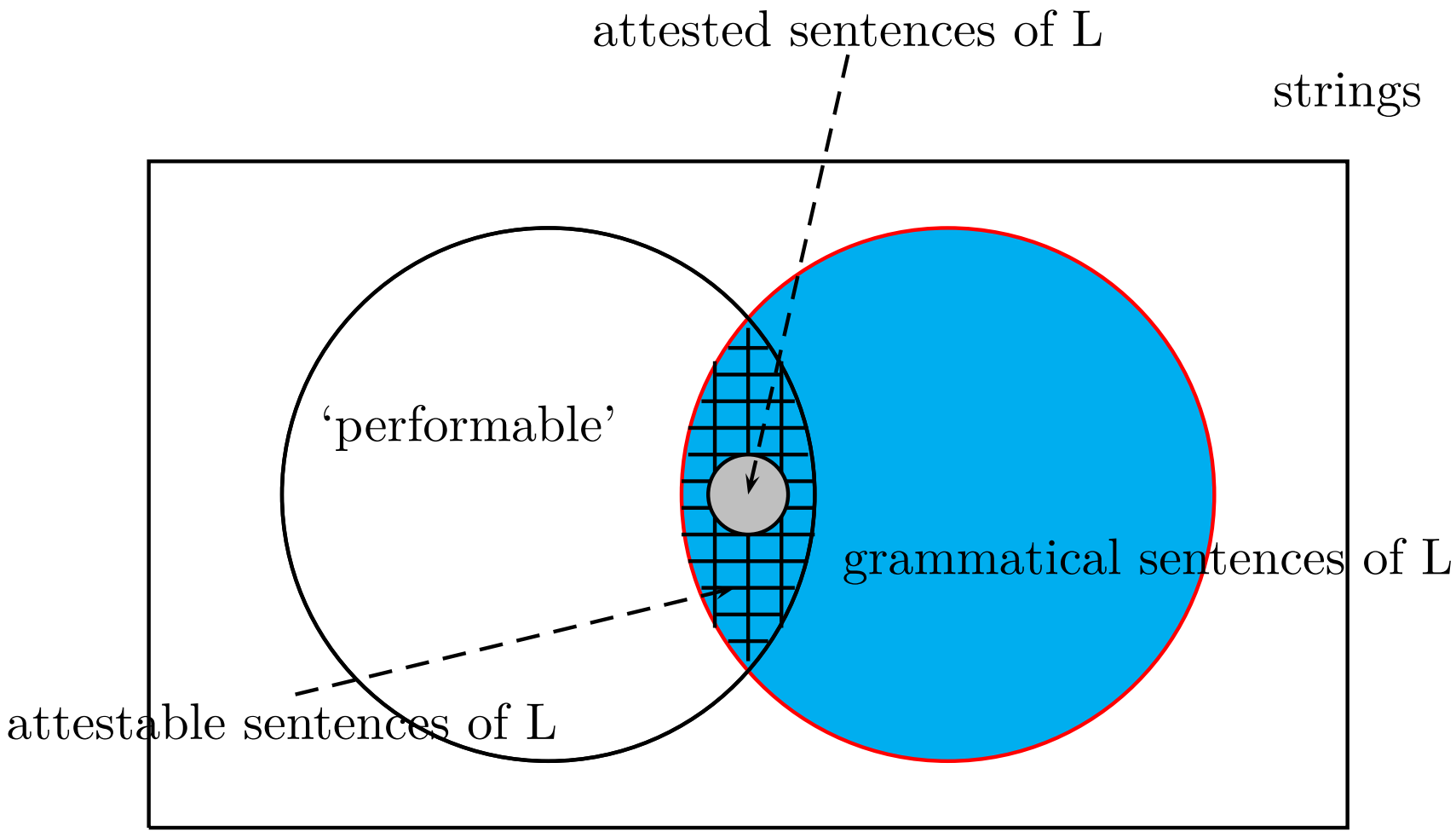


FIGURE 2 The shape of a linguistic theory

Ronald Kaplan (1987/1995:346-7)

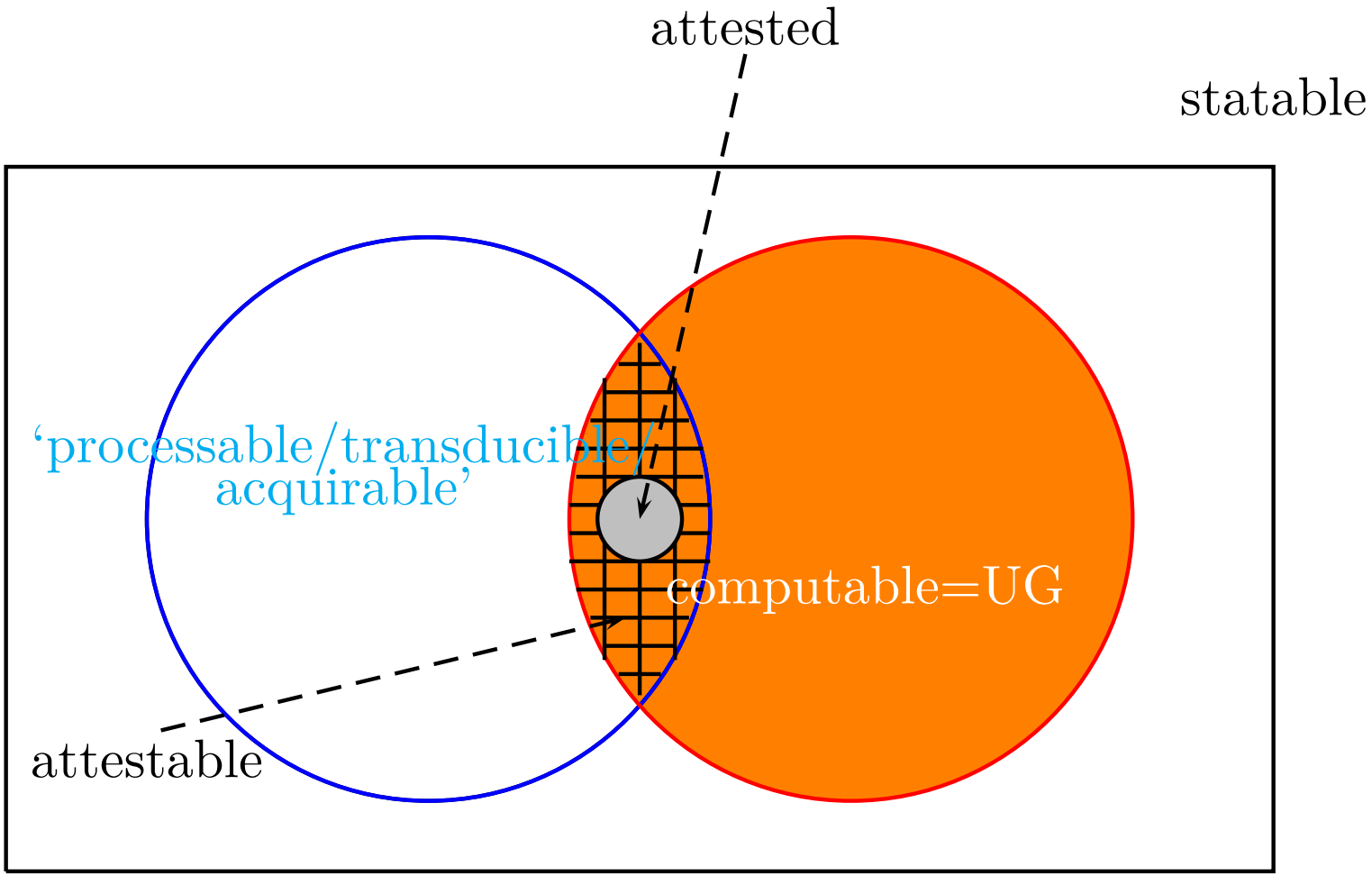
A formal theory may have a relatively smooth outline …[t]hen you start taking chunks out of it …because you claim that no human language or grammar has such and such a property. …It's a mistake to carry premature and unjustified substantive hypotheses into our computational and mathematical work, especially if it leads to mathematically complex, even if more restrictive, theories. …[W]e should be wary of the seduction of substance.

The analogy again: possible sentences



Note the nice round blue theory of grammar of L

The analogy again: possible languages



Note the nice round orange theory of UG

- Don't take out chunks of your nice theory of UG (Human Language Faculty) because of properties of Memory, Audition, Learning, etc.

- Don't take out chunks of your nice theory of UG (Human Language Faculty) because of properties of Memory, Audition, Learning, etc.
- We expect this effect from a modular theory

- Don't take out chunks of your nice theory of UG (Human Language Faculty) because of properties of Memory, Audition, Learning, etc.
- We expect this effect from a modular theory
- So PHONOLOGICAL exchange / polarity processes are perhaps phonologically possible, but can never be found (current work w/ Kyle Gorman) ...

- Don't take out chunks of your nice theory of UG (Human Language Faculty) because of properties of Memory, Audition, Learning, etc.
- We expect this effect from a modular theory
- So PHONOLOGICAL exchange / polarity processes are perhaps phonologically possible, but can never be found (current work w/ Kyle Gorman) ...

  αF $\rightarrow$ $-\alpha$F

Outline

Poverty of the Stimulus

- Linguists tend to focus on the positive, the scope of knowledge, the innate endowment that makes kids seem smart

Poverty of the Stimulus

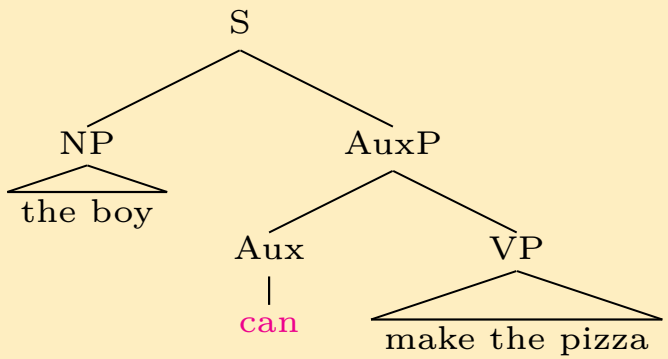
- Linguists tend to focus on the positive, the scope of knowledge, the innate endowment that makes kids seem smart
- This talk:

Poverty of the Stimulus

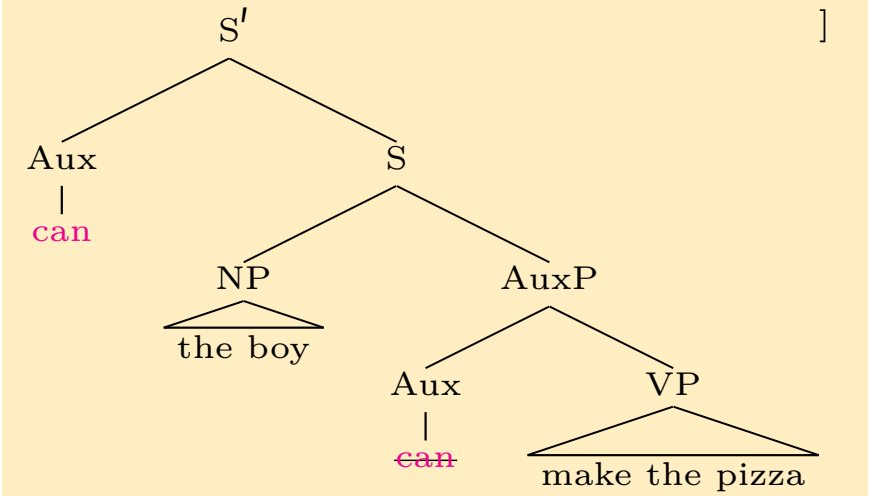
- Linguists tend to focus on the positive, the scope of knowledge, the innate endowment that makes kids seem smart
- This talk:
  - Accentuate the **negative**, the limits, what kids *can't* do

Yes/No questions transformationally

Deep Structure



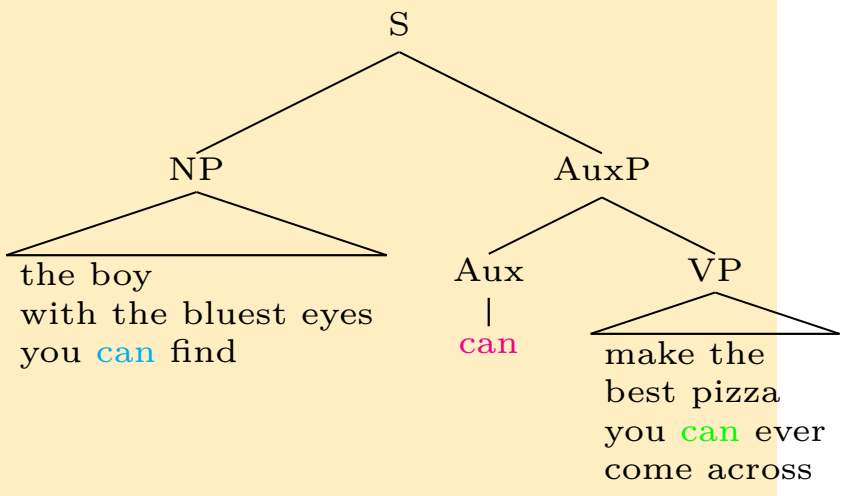
Surface Structure



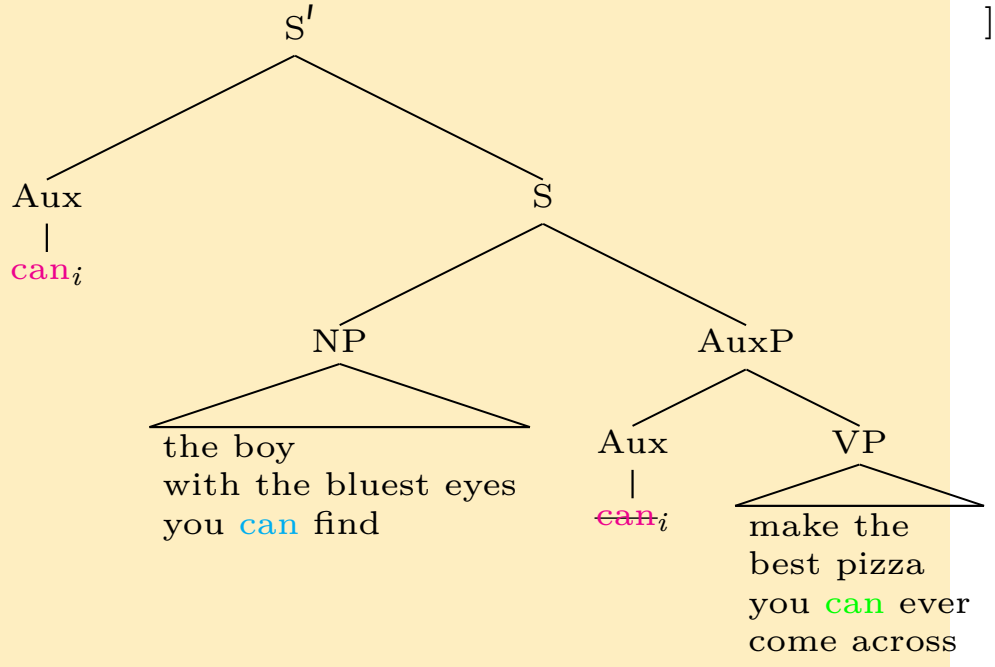
Yes/No questions in sentences with more than one Aux

The transformation is STRUCTURE DEPENDENT—it finds the Aux of the main sentence

Deep Structure



Surface Structure



Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read t offer to compose the poem for the biologist who has cured the disease that could kill many people?

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read t offer to compose the poem for the biologist who has cured the disease that could kill many people?

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read t offer to compose the poem for the biologist who has cured the disease that could kill many people?

AUX-inversion as a capacity

- Extensionally equivalent analyses for stimuli

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read *t* offer to compose the poem for the biologist who has cured the disease that could kill many people?

AUX-inversion as a capacity

- Extensionally equivalent analyses for stimuli
- Data underdetermines the grammar for the kid (in many ways), yet

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read t offer to compose the poem for the biologist who has cured the disease that could kill many people?

AUX-inversion as a capacity

- Extensionally equivalent analyses for stimuli
- Data underdetermines the grammar for the kid (in many ways), yet
- Kid is capable of acquiring the structure-dependent model

Positive thinking

- The woman who can write books that everyone should read did offer to compose the poem for the biologist who has cured the disease that could kill many people.
- Did the woman who can write books that everyone should read *t* offer to compose the poem for the biologist who has cured the disease that could kill many people?

AUX-inversion as a capacity

- Extensionally equivalent analyses for stimuli
- Data underdetermines the grammar for the kid (in many ways), yet
- Kid is capable of acquiring the structure-dependent model
  - Can extend the rule to 5 levels of embedding or 11 or ...

The power of *negative* thinking

AUX-inversion as a limitation

- Kid is *incapable* of acquiring the non-structure-dependent grammar compatible with actual stimulus

Outline

I-language Perspective (Chomsky 1986)

- Individual

Isac & Reiss (2013)

I-language Perspective (Chomsky 1986)

- Individual
- Internal

Isac & Reiss (2013)

I-language Perspective (Chomsky 1986)

- Individual
- Internal
- Intensional

Isac & Reiss (2013)

I-language Perspective (Chomsky 1986)

- Individual
- Internal
- Intensional
- (Not INNATE)

Isac & Reiss (2013)

A ‘general smarts’ psychologist

Internalism $\not\Rightarrow$ UG

Innateness and I-language

A 'general smarts' psychologist

Internalism $\not\Rightarrow$ UG

however...

What's innate is internal

- UG $\Rightarrow$ Internalism

Innateness and I-language

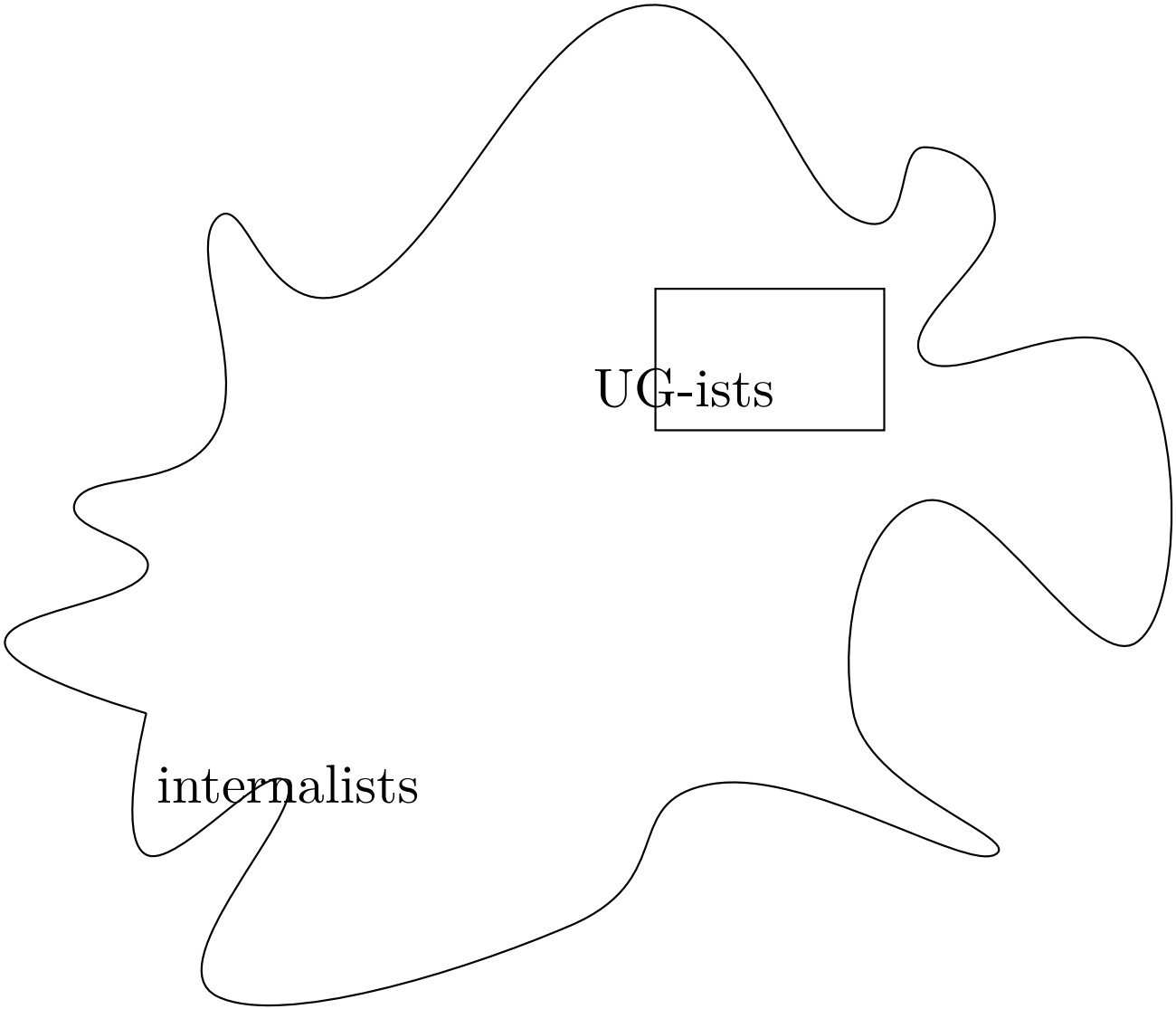
A 'general smarts' psychologist

Internalism $\not\Rightarrow$ UG

however...

What's innate is internal

- UG $\Rightarrow$ Internalism
- $\therefore$No-Internalism $\Rightarrow$ No-UG


UG-ists
internalists

Achtung!

Crazy Platonist Philosophers do exist!

They think that numbers are universal but exist outside of human cognition:

- '2' has and always will exist.

Achtung!

Crazy Platonist Philosophers do exist!

They think that numbers are universal but exist outside of human cognition:

- '2' has and always will exist.
- Same for $134.\overline{142857}$.

Achtung!

Crazy Platonist Philosophers do exist!

They think that numbers are universal but exist outside of human cognition:

- '2' has and always will exist.
- Same for $134.\overline{142857}$.
- Same for 'square' and 'triangle'.

Current anti-UG phonology

Current anti-UG phonology rejects nativism because of confusion about

- Internalism

Current anti-UG phonology

Current anti-UG phonology rejects nativism because of confusion about

- Internalism
  - Denial of PoS is (in part) a symptom of denial (implicit or explicit) of internalism.

Current anti-UG phonology

Current anti-UG phonology rejects nativism because of confusion about

- Internalism
  - Denial of PoS is (in part) a symptom of denial (implicit or explicit) of internalism.
- Intensionalism

Current anti-UG phonology

Current anti-UG phonology rejects nativism because of confusion about

- Internalism
  - Denial of PoS is (in part) a symptom of denial (implicit or explicit) of internalism.
- Intensionalism
  - Denial of PoS is (in part) a symptom of lack of appreciation for intensionalism.

Outline

The origin of speech (2008: 41)

however much poverty of the stimulus exists for language in general, there is none of it in the domain of the structure of words, the unit of communication I am most concerned with. Infants hear all the words they expect to produce. Thus, the main proving ground for UG does not include phonology

The origin of speech (2008: 41)

> *however much poverty of the stimulus exists for language in general, there is none of it in the domain of the structure of words, the unit of communication I am most concerned with. Infants hear all the words they expect to produce. Thus, the main proving ground for UG does not include phonology*

- Do Turkish kids hear *evlerimizdekilerinki* 'the one belonging to the ones in our houses' with root *ev* 'house' (Hankamer, 1989, p. 397)

The origin of speech (2008: 41)

> *however much poverty of the stimulus exists for language in general, there is none of it in the domain of the structure of words, the unit of communication I am most concerned with. Infants hear all the words they expect to produce. Thus, the main proving ground for UG does not include phonology*

- Do Turkish kids hear *evlerimizdekilerinki* 'the one belonging to the ones in our houses' with root *ev* 'house' (Hankamer, 1989, p. 397)
- Do Shona kids hear all 10^{33} forms of a verb they can parse and generate if need be? (David Odden, p.c.)

The Emergence of Distinctive Features, 2008

- *Many of the arguments for UG in other domains do not hold for phonology. For example, there is little evidence of a learnability problem in phonology (see Juliette Blevins 2004 for discussion).* p. 33

The Emergence of Distinctive Features, 2008

- *Many of the arguments for UG in other domains do not hold for phonology. For example, there is little evidence of a learnability problem in phonology (see Juliette Blevins 2004 for discussion).* p. 33
- *[Most of the evidence for] UG is not related to phonology, and phonology has more of a* ***g****uilt-by-association status with respect to innateness.* p. 34

Archangeli & Pulleyblank

⇒'Phonology without universal grammar'⇐ (2015)

- *See Mielke [2004/8] on why features cannot be innately defined, but must be learned*

Archangeli & Pulleyblank

⇒'Phonology without universal grammar'⇐ (2015)

- *See Mielke [2004/8] on why features cannot be innately defined, but must be learned*
- *[Children face] the challenge of isolating specific sounds from the sound stream*

Archangeli & Pulleyblank

⇒'Phonology without universal grammar'⇐ (2015)

- *See Mielke [2004/8] on why features cannot be innately defined, but must be learned*
- *[Children face] the challenge of isolating specific sounds from the sound stream*
- *the predictions of [Emergent Grammar] fit the data better than do the predictions of UG.*

'Universal grammar and syntax/phonology parallelisms' (2006)

*Phonological objects and relations are **internalisable**: there is no poverty of the stimulus argument in phonology. No phonological knowledge is given by UG.*

Blevins 2004:235

Evolutionary Phonology

Within the domain of sounds, there is no poverty of the stimulus. [I offer] general arguments against the "poverty of stimulus" in phonology, ...[there is no evidence that] regular phonological alternations cannot be acquired on the basis of generalizations gleaned directly from auditory input.

Blevins 2004:235

Evolutionary Phonology

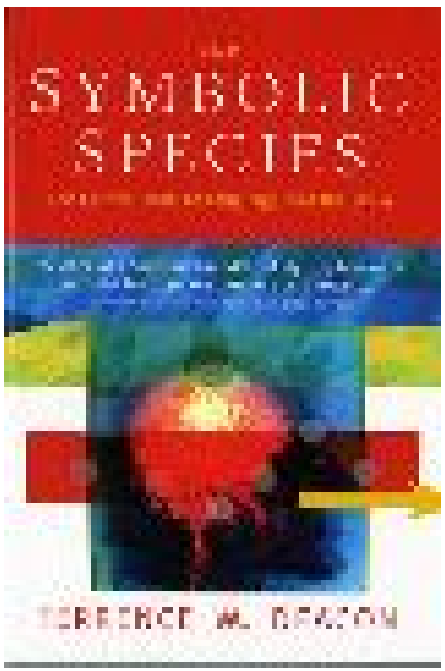
Within the domain of sounds, there is no poverty of the stimulus. [I offer] general arguments against the "poverty of stimulus" in phonology, …[there is no evidence that] regular phonological alternations cannot be acquired on the basis of generalizations gleaned directly from auditory input.

- Obviously you need more than auditory input to get alternations—you need meaning.
- Auditory input is not linguistic input.

The scourge of externalism

These all cite Deacon's *The Symbolic Species* (1997)

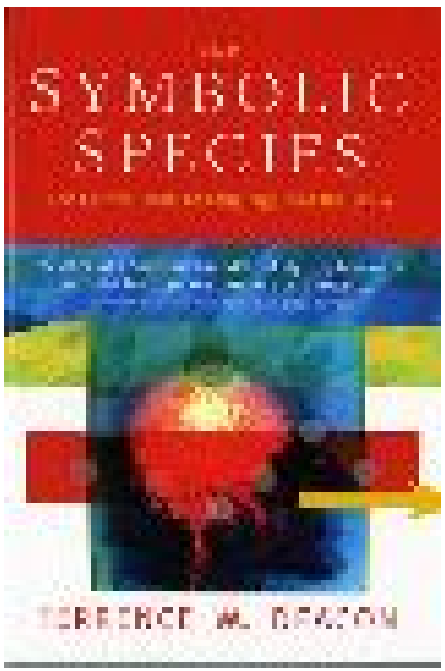
- Archangeli & Pulleyblank



The scourge of externalism

These all cite Deacon's *The Symbolic Species* (1997)

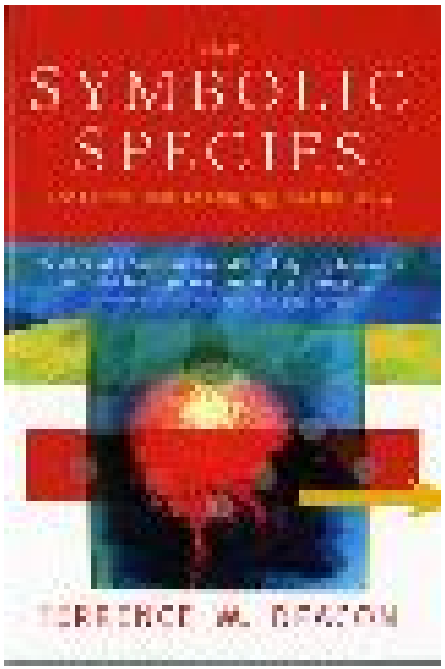
- Archangeli & Pulleyblank
- Mielke



The scourge of externalism

These all cite Deacon's *The Symbolic Species* (1997)

- Archangeli & Pulleyblank
- Mielke
- Blevins



Externalist views of language:

From Terrence Deacon's *The Symbolic Species* (1997)

I think Chomsky and his followers have articulated a central conundrum about language learning, but they offer an answer that inverts cause and effect. They assert that the source of prior support for language acquisition must originate from inside the brain, on the unstated assumption that there is no other possible source. But there is another alternative: that the extra support for language learning is vested neither in the brain of the child nor in the brains of parents or teachers, but outside brains in language itself. [105]

Externalist views of language:

From Terrence Deacon's *The Symbolic Species* (1997), 107

> *Over countless generations languages should have become better and better adapted to people, so that people need to make minimal adjustments to adapt to them.*

Thus language is not in the head, not biological. What can any of this mean?

Externalist views of language:

From Terrence Deacon's *The Symbolic Species* (1997), 107

> *Over countless generations languages should have become better and better adapted to people, so that people need to make minimal adjustments to adapt to them.*

Thus language is not in the head, not biological. What can any of this mean? Did people adapt to their noses? Vice versa?

Pullum and Scholz on I-language

- Pullum and Scholz (2001) want linguists should study things like Standard English, "the ordinary, common-sense notion of a language under which we can say that *The Times* in the UK, *The New York Times* in the USA, *The Sydney Morning Herald* in Australia, and other newspapers around the world, all publish in the same language."

Pullum and Scholz on I-language

- Pullum and Scholz (2001) want linguists should study things like Standard English, "the ordinary, common-sense notion of a language under which we can say that *The Times* in the UK, *The New York Times* in the USA, *The Sydney Morning Herald* in Australia, and other newspapers around the world, all publish in the same language."
- Rather than a "stipulated technical concept" like I-language, they favor "the common-sense concept of a language, the one under which millions of different people may be correctly described as speakers of the same language."

President of the LSA!

Linguistic theory must account not just for the core of universal grammar, but also for the periphery of particular grammars. Children do in fact learn languages, real languages, and not what Chomsky has called I-languages, idealized systems that are nowhere completely instantiated. These real languages, we might call them R-languages, are presented more or less immediately to the mind of the native speaker, and form the basis for the creative work that goes into language development...

Huh?

...the universal rules or implicit axioms of grammar aren't really stored or located anywhere [Deacon, 1997: 115, cited by Blevins, 2004]

Where is language?

Wider than the sky: the phenomenal gift of consciousness, Edelman 2004

"Language helped the brain evolve"

Where is language?

Wider than the sky: the phenomenal gift of consciousness, Edelman 2004

"Language helped the brain evolve"

—but language is *part of* the brain under the I-language view

Where is language?

Wider than the sky: the phenomenal gift of consciousness, Edelman 2004

"Language helped the brain evolve"

—but language is *part of* the brain under the I-language view
—like saying "the pinky helped the body evolve".

‘Real scientist’ on language evolution

Wider than the sky (Edelman, 2004)

> *In freeing the upper extremities from brachiation (climbing or hanging) or walking, a whole precursor set involving the interpretation of gestures by the self and by others may have been opened up for early hominines [p.102]*

Not as entertaining as Rudyard Kipling

Wider than the sky (Edelman, 2004)

Whether infants who have learned to walk, and have their upper limbs free, develop similar capabilities before the exercise of extensive speech acts is a question that remains. The acquisition of language may be enormously facilitated by the development of conscious imagery related to movements and motor control. Almost certainly, concepts of objects, events, and succession must exist in a child's mind before the exercise of language. According to these ideas, the sequences of actions of the free upper extremities may prepare the basal ganglion–cortical loops for the emergence of syntactical sequences, establishing what might be called a protosyntax.

About as explanatory as Kipling

Edelman (2004)

Clearly, one of the largest steps towards the acquisition of true language is the realization that an arbitrary token—a gesture or a word—stands for a thing or an event. When a sufficiently large lexicon of such tokens is accumulated, higher-order consciousness can greatly expand in range. Association can be made by metaphor, and with ongoing activity, early metaphor can be transformed into more precise categorization of intrapersonal and interpersonal experience. The gift of narrative and an expanded sense of temporal succession then follow. [p.102-3]

The correct response?

Ignore Blevins; Mielke; Archangeli & Pulleyblank

- They are not talking about I-language

The correct response?

Ignore Blevins; Mielke; Archangeli & Pulleyblank

- They are not talking about I-language
- They are not talking about the same thing as us

The correct response?

Ignore Blevins; Mielke; Archangeli & Pulleyblank

- They are not talking about I-language
- They are not talking about the same thing as us
- Not our problem to figure out what they are talking about

The correct response?

Ignore Blevins; Mielke; Archangeli & Pulleyblank

- They are not talking about I-language
- They are not talking about the same thing as us
- Not our problem to figure out what they are talking about

The correct response?

Ignore Blevins; Mielke; Archangeli & Pulleyblank

- They are not talking about I-language
- They are not talking about the same thing as us
- Not our problem to figure out what they are talking about

They *do* have some legitimate gripes with how nativist phonology has been pursued—think of OT contraints

- No theory of what is acquired
- No engagement with well-established arguments about PoS
  - Kant, Fodor, Chomsky, Jackendoff, etc.

Knowledege of Language (Chomsky, 1986)

Chomsky rejects the externalist, E-language approach into which Pullum and Scholz's version of common sense leads them, since it appears to Chomsky that "the concept raises a host of new problems and it is not at all clear whether they are worth addressing or trying to solve, given the artificial nature of the construct and its apparent uselessness for the theory of language."

Common sense? Ha! ((Nagel and Newman, 1958))

- "as we all know, intuition is not a safe guide: it cannot properly be used as a criterion of either truth or fruitfulness in scientific explorations"
- "in developing consistent systems familiarity and intuitive clarity are weak reeds to lean on"

Why does this matter

- *Linguists* cite Deacon (who knows nothing about language)

Why does this matter

- *Linguists* cite Deacon (who knows nothing about language)
- Edelman won a Nobel Prize—but he rejects mental representations, “symbols in the head”

Why does this matter

- *Linguists* cite Deacon (who knows nothing about language)
- Edelman won a Nobel Prize—but he rejects mental representations, "symbols in the head"
- If language is outside the head, then segments and features are outside the head

Why does this matter

- *Linguists* cite Deacon (who knows nothing about language)
- Edelman won a Nobel Prize—but he rejects mental representations, "symbols in the head"
- If language is outside the head, then segments and features are outside the head
- Big step backwards from Jespersen, Sapir, Chomsky, Hammarberg, Jackendoff, etc.

Jackendoff (2007)

Naturally, both neuroscientists and linguists would love to know how these [linguistic] structures are instantiated in neural tissue and neural activity. But this is not a question that can be answered at present. In particular, even if we know where a structure is localized in the brain—the sort of information that neural imaging can provide—we do not know how the brain instantiates the structure. I think it is worth emphasizing our extreme ignorance here. We don't have the slightest idea how even the most elementary units of linguistic structure such as speech sounds can be instantiated neurally: how speech sounds are stored and how they are processed.

Jackendoff (2007)

Some neuroscientists [specifically refers to Deacon in a footnote–cr] say we are beyond this stage of inquiry, that we don't need to talk about "symbols in the head" anymore. I firmly disagree. We know that language is organized into speech sounds and that speech sounds are only the first step in analyzing linguistic structure. As far as I know, there exist absolutely no attempts to account for even this trivial degree of linguistic complexity in neural terms, and speech sounds only scratch the surface. In my opinion, it is the height of scientific irresponsibility to totally dismiss linguistic theory, claiming that some toy system (say a computational neural network) will eventually scale up to the full complexity of language. A linguist who made comparably ignorant claims about the brain would be a laughingstock. End of sermon.

Outline

Same old arguments

From authority...

- "In fact, physicalists among phoneticians are all closet mentalists."
  Bromberger and Halle 1986, 'On the Relationship of Phonology and Phonetics'

Same old arguments

From authority...

- "In fact, physicalists among phoneticians are all closet mentalists."
  Bromberger and Halle 1986, 'On the Relationship of Phonology and Phonetics'
  - They make use of 'word, utterance, syllable, sentence,' etc.

Same old arguments

From authority...

- "In fact, physicalists among phoneticians are all closet mentalists."
  Bromberger and Halle 1986, 'On the Relationship of Phonology and Phonetics'
  - They make use of 'word, utterance, syllable, sentence,' etc.
- "Language, as far as I can tell, is *all* construction."
  Ray Jackendoff 1992, 'The problem of reality', p.164

Same old arguments

From authority...

- "In fact, physicalists among phoneticians are all closet mentalists."
  Bromberger and Halle 1986, 'On the Relationship of Phonology and Phonetics'
  - They make use of 'word, utterance, syllable, sentence,' etc.
- "Language, as far as I can tell, is *all* construction."
  Ray Jackendoff 1992, 'The problem of reality', p.164
- Objects of perception conform to the mind—Kant, Chomsky, Fodor, Jackendoff

Outline

Rationalism and Empiricism

Let's use phonology as an example

- Phonetics: study of the articulation and acoustics of speech—spectrograms, muscle control, etc.

Rationalism and Empiricism

Let's use phonology as an example

- Phonetics: study of the articulation and acoustics of speech—spectrograms, muscle control, etc.
- Phonology: cognitive account of patterns of speech sounds and relations among speech sounds

Rationalism and Empiricism

Let's use phonology as an example

- Phonetics: study of the articulation and acoustics of speech—spectrograms, muscle control, etc.
- Phonology: cognitive account of patterns of speech sounds and relations among speech sounds
- Commonsense: you can't do phonology without phonetics—this is why pretty much every phonology text starts with a review of phonetics.

The priority of phonology—RATIONALISM

Commonsense is wrong (again)

- Hammarberg (1976): Phonology is logically prior to phonetics. Phonetics could not exist without the segment [or feature or syllable]. But phonetics does not give us the segment. Rather it is the segment that gives us phonetics.

The priority of phonology—RATIONALISM

Commonsense is wrong (again)

- Hammarberg (1976): Phonology is logically prior to phonetics. Phonetics could not exist without the segment [or feature or syllable]. But phonetics does not give us the segment. Rather it is the segment that gives us phonetics.
- Can't talk about 'fronted [k]' or 'backed [k]' w/o category [k]

The priority of phonology—RATIONALISM

Commonsense is wrong (again)

- Hammarberg (1976): Phonology is logically prior to phonetics. Phonetics could not exist without the segment [or feature or syllable]. But phonetics does not give us the segment. Rather it is the segment that gives us phonetics.
- Can't talk about 'fronted [k]' or 'backed [k]' w/o category [k]
  - For H 'we' is the linguist–we adopt the 'little linguist' view

The priority of phonology—RATIONALISM

Commonsense is wrong (again)

- Hammarberg (1976): Phonology is logically prior to phonetics. Phonetics could not exist without the segment [or feature or syllable]. But phonetics does not give us the segment. Rather it is the segment that gives us phonetics.
- Can't talk about 'fronted [k]' or 'backed [k]' w/o category [k]
  - For H 'we' is the linguist–we adopt the 'little linguist' view
- Phonological generalizations cannot be ultimately based on phonetic notions, since the phonetic notions are defined in terms of phonological categories

Hammarberg 1976: 354

Chomskian linguistics is explicitly anti-empiricist, and all indications are that current philosophy of science is moving toward a rejection of the empiricist programme (Fodor 1968, pp. xiv ff). A key feature of the new programme is exactly a reevaluation of the concept of observation. Observations are now held to be judgments, and these judgments are made in terms of the criteria provided by the paradigm. Thus the taxonomy of a discipline is to be regarded as imposed from above, rather than emerging from below, i.e., rather than emerging in the form of brute facts before the unprejudiced eyes or ears of the researcher. The relevance of this to the study of phonetics and phonology should be obvious: the concept of the segment, which is indispensable to phonetics and phonology, is a creature of the paradigm, not of the raw data.

Rationalism and the segment

Hammarberg 1976:354

[I]t should be perfectly obvious by now that segments do not exist outside the human mind. [354]

Instrumentalism and realism

Are segments then just 'fictions'? (355)

> *there would be little value in such an approach. Science aims for a theory of the real, and to base one's descriptions and generalizations on a fictional taxonomy could only lead to one's theories being fictional as well. [355]*

Hammarberg (1981), 'The cooked and the raw'

No such thing as *raw* data. Revisits the "Kantian claim that objects conform to our modes of cognition" again drawing on Chomsky, as well as on modern physics:

Hammarberg (1981), 'The cooked and the raw'

No such thing as *raw* data. Revisits the "Kantian claim that objects conform to our modes of cognition" again drawing on Chomsky, as well as on modern physics:

- *The 'furniture of the world' does not come prepackaged in the form of individuals with properties, apart from human intervention: [e]ither the analysis provided by the cognitive system that we might call 'common sense understanding' or the more self-conscious idealizations of the scientist seeking to comprehend some aspect of physical or mental reality (Chomsky, 1980).*

Hammarberg (1981), 'The cooked and the raw'

No such thing as *raw* data. Revisits the "Kantian claim that objects conform to our modes of cognition" again drawing on Chomsky, as well as on modern physics:

- *The 'furniture of the world' does not come prepackaged in the form of individuals with properties, apart from human intervention: [e]ither the analysis provided by the cognitive system that we might call 'common sense understanding' or the more self-conscious idealizations of the scientist seeking to comprehend some aspect of physical or mental reality (Chomsky, 1980).*
- *"The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with facts established by experiment" [Bernard d'Espagnat, The quantum theory and reality 1979]*

Martian scientists and features

What's the generalization?

- *x* occurs /__i, u, a, % *vs.*

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT
  - y occurs before a CONSONANT and x occurs ELSEWHERE

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT
  - y occurs before a CONSONANT and x occurs ELSEWHERE
    - Not in the signal—think about spectrograms of /a, n, p, s, r, l, k, v/

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT
  - y occurs before a CONSONANT and x occurs ELSEWHERE
    - Not in the signal—think about spectrograms of /a, n, p, s, r, l, k, v/
    - Howard's "big leap" also applies from noise to feature

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT
  - y occurs before a CONSONANT and x occurs ELSEWHERE
    - Not in the signal—think about spectrograms of /a, n, p, s, r, l, k, v/
    - Howard's "big leap" also applies from noise to feature
    - UG tells us what to count. This is already a PoS argument.

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a CONSONANT
  - y occurs before a CONSONANT and x occurs ELSEWHERE
    - Not in the signal—think about spectrograms of /a, n, p, s, r, l, k, v/
    - Howard's "big leap" also applies from noise to feature
    - UG tells us what to count. This is already a PoS argument.
    - Epistemic boundedness—UG determines what we can't count

Martian scientists and features

What's the generalization?

- x occurs /___i, u, a, % *vs.*
- y occurs / ___p,t,k,b,d,g,n,m,r,l,s,z,ʃ,ʒ
- Which is the underlying form, x or y?
- Which occurs in more environments?
- $14 \overset{?}{>} 4$
  - y occurs in ONE environment; x in TWO: /x/ →[y] before a Consonant
  - y occurs before a Consonant and x occurs Elsewhere
    - Not in the signal—think about spectrograms of /a, n, p, s, r, l, k, v/
    - Howard's "big leap" also applies from noise to feature
    - UG tells us what to count. This is already a PoS argument.
    - Epistemic boundedness—UG determines what we can't count
    - e.g., a property shared by an onset t and a coda p (Chomsky and Halle (1965))

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."
- "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."
- "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"
- "Isn't that precisely what you have done with relativity?" I asked in some surprise...

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."
- "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"
- "Isn't that precisely what you have done with relativity?" I asked in some surprise...
- "Possibly I did use this kind of reasoning," Einstein admitted, "but it is nonsense all the same....In reality the very opposite happens. It is the theory which decides what we can observe."

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."
- "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"
- "Isn't that precisely what you have done with relativity?" I asked in some surprise...
- "Possibly I did use this kind of reasoning," Einstein admitted, "but it is nonsense all the same....In reality the very opposite happens. It is the theory which decides what we can observe."

Einstein and Heisenberg: For scientists and babies

- Heisenberg: "We cannot observe electron orbits inside the atom...Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits."
- "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"
- "Isn't that precisely what you have done with relativity?" I asked in some surprise...
- "Possibly I did use this kind of reasoning," Einstein admitted, "but it is nonsense all the same....In reality the very opposite happens. It is the theory which decides what we can observe."

and it's UG that decides what kids can learn

What do kids store?

What do kids actually store?

- Never what they hear

What do kids store?

What do kids actually store?

- Never what they hear
- What they never hear

Children *never* store what they hear

Word level

- Speaker identity

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality
- Intonation

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality
- Intonation
  - He went to the *park*?

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality
- Intonation
  - He went to the *park*?
  - He went to the *park*.

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality
- Intonation
  - He went to the *park*?
  - He went to the *park*.
  - The have to store forms w/o intonation—but they never encounter forms without intonation.

Children *never* store what they hear

Word level

- Speaker identity
- Voice quality
- Intonation
  - He went to the *park*?
  - He went to the *park*.
  - The have to store forms w/o intonation—but they never encounter forms without intonation.
  - I saw a pangolin. ⇝ What's a pangolin?

They store what they *never* hear

Palauan ‘cover’

a. Suffix [-áll], stress on suffix: dəŋəbáll
b. Suffix [-l], stress on second vowel of root: dəŋóbl
c. Prefix [mə-], stress on first vowel of the root: mədáŋəb

Outline

The 8 Turkish vowels

a. ip
b. kıl
c. sap
d. uç
e. son
f. öç
g. gül
h. ek

Describing Vowels

	-Back		+Back	
	-Round	+Round	-Round	+Round
+High	i	ü	ɪ	u
-High	e	ö	a	o

(Keep this in mind—8 vowels with 3 features.)

Features have articulatory and acoustic correlates

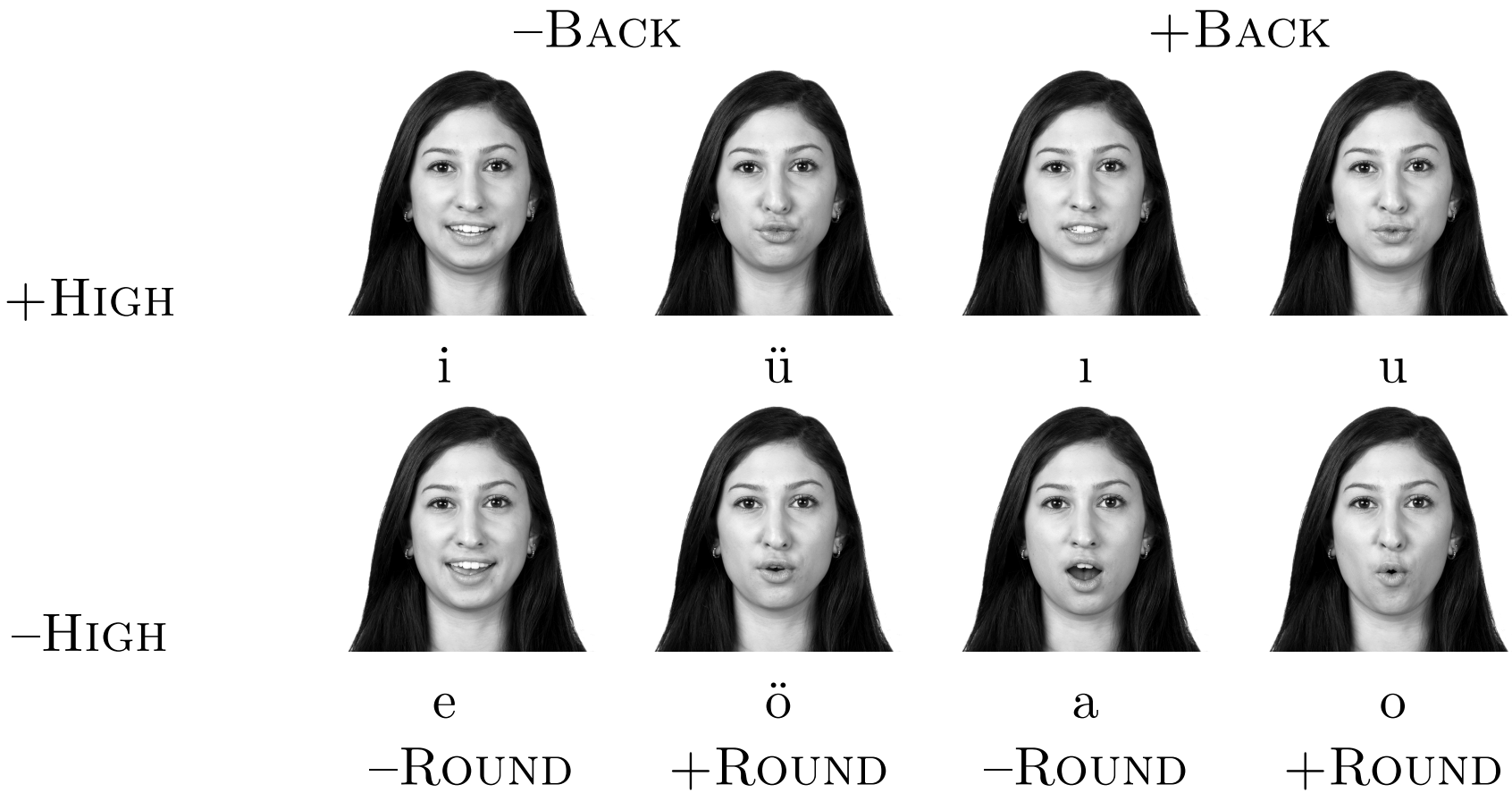


Figure: A native speaker pronouncing the eight Turkish surface vowels.

- /i/ − Back + High − Round ...
- /u/ + Back + High + Round ...
- /o/ + Back − High + Round ...
- and so on.

A segment IS a set of features

- That's part of our explicit representational theory

A segment IS a set of features

- That's part of our explicit representational theory
- Consistent—no incompatible values

A segment IS a set of features

- That's part of our explicit representational theory
- Consistent—no incompatible values
  - +F and -F

A segment IS a set of features

- That's part of our explicit representational theory
- Consistent—no incompatible values
  - +F and -F

$$/i/ = \left\{ \begin{array}{c} \text{-BACK} \\ \text{-ROUND} \\ \text{+HIGH} \\ \vdots \end{array} \right\} \quad /u/ = \left\{ \begin{array}{c} \text{+BACK} \\ \text{+ROUND} \\ \text{+HIGH} \\ \vdots \end{array} \right\}$$

Turkish singular / plural pairs

singular	plural	meaning
dev	devler	giant
kek	kekler	cake
cep	cepler	pocket
çek	çekler	check
ters	tersler	contrary
can	canlar	soul
tarz	tarzlar	type
kap	kaplar	recipient
saç	saçlar	hair
aşk	aşklar	love

Turkish singular / plural pairs

singular	plural	meaning
dev	devler	giant
kek	kekler	cake
cep	cepler	pocket
çek	çekler	check
ters	tersler	contrary
can	canlar	soul
tarz	tarzlar	type
kap	kaplar	recipient
saç	saçlar	hair
aşk	aşklar	love

Turkish singular / plural pairs

singular	plural	meaning
dev	devler	giant
kek	kekler	cake
cep	cepler	pocket
çek	çekler	check
ters	tersler	contrary
can	canlar	soul
tarz	tarzlar	type
kap	kaplar	recipient
saç	saçlar	hair
aşk	aşklar	love

Vowel Harmony I: The vowel of the suffix, *-ler/-lar* is identical to the preceding vowel.

More Turkish singular / plural pairs

singular	plural	meaning
ip	ipler	rope
öç	öçler	vengeance
gül	güller	rose
ek	ekler	junction
kıl	kıllar	body hair
sap	saplar	stalk
uç	uçlar	edge
son	sonlar	end

Turkish singular / plural pairs

singular	plural	meaning
ip	ipler	rope
öç	öçler	vengeance
gül	güller	rose
ek	ekler	junction
kıl	kıllar	body hair
sap	saplar	stalk
uç	uçlar	edge
son	sonlar	end

Turkish singular / plural pairs

singular	plural	meaning
ip	ipler	rope
öç	öçler	vengeance
gül	güller	rose
ek	ekler	junction
kıl	kıllar	body hair
sap	saplar	stalk
uç	uçlar	edge
son	sonlar	end

Vowel Harmony: The vowel of the suffix is identical to the preceding vowel w.r.t. the feature Back .

- i, e, ü, ö are -Back (i, e, y, œ)

Turkish singular / plural pairs

singular	plural	meaning
ip	ipler	rope
öç	öçler	vengeance
gül	güller	rose
ek	ekler	junction
kıl	kıllar	body hair
sap	saplar	stalk
uç	uçlar	edge
son	sonlar	end

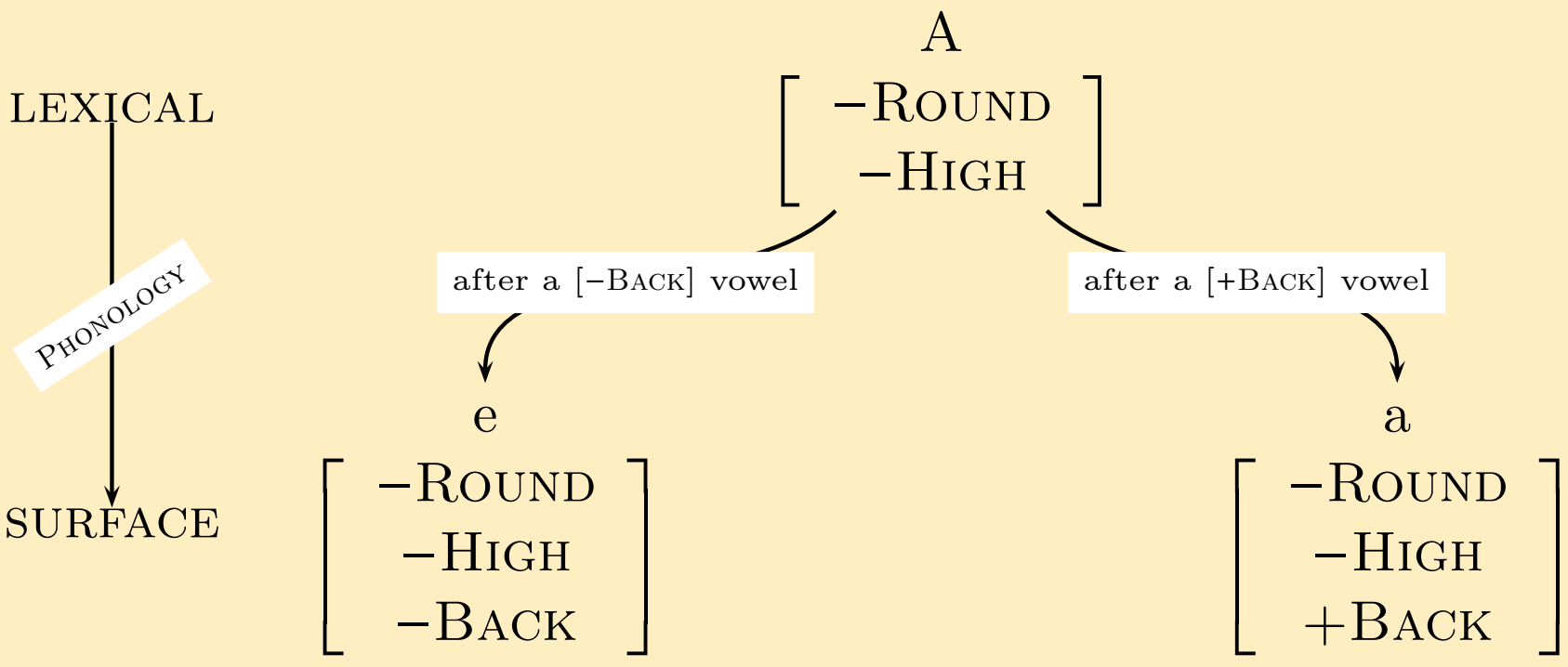
Vowel Harmony: The vowel of the suffix is identical to the preceding vowel w.r.t. the feature Back .

- i, e, ü, ö are -Back (i, e, y, œ)
- u, o, ı, a are +Back (u, o, ɯ, a)

Outline

Underspecification analysis of vowel of plural suffix

They NEVER hear [A], but they store that vowel!



Outline

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)
- Invariance—constant properties that define a segment

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)
- Invariance—constant properties that define a segment
- Lack of invariance—we can't find such properties

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)
- Invariance—constant properties that define a segment
- Lack of invariance—we can't find such properties
- Problem of the lack of invariance—that's a problem for an empiricist

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)
- Invariance—constant properties that define a segment
- Lack of invariance—we can't find such properties
- Problem of the lack of invariance—that's a problem for an empiricist

Problem of the lack of invariance

What's the problem?

- 'Variance'—speech segments differ according to context
  - (btw, so do features: e.g., more nasalization in lower vowels)
- Invariance—constant properties that define a segment
- Lack of invariance—we can't find such properties
- Problem of the lack of invariance—that's a problem for an empiricist

Appelbaum (2006):"nearly half a century of sustained effort in a variety of theoretical perspectives has failed to solve this problem"

Features and arm-raising!

Cudsworth's *cognoscitive* powers

In and outside of language

- "It is idle to seek a mind-independent construct that corresponds to the syllable /ba/" [Chomsky 2009:27)

Cudsworth's *cognoscitive* powers

In and outside of language

- "It is idle to seek a mind-independent construct that corresponds to the syllable /ba/" [Chomsky 2009:27)
- "It should be perfectly obvious by now that segments do not exist outside the human mind." [Hammarberg 1976]

Cudsworth's *cognoscitive* powers

In and outside of language

- "It is idle to seek a mind-independent construct that corresponds to the syllable /ba/" [Chomsky 2009:27)
- "It should be perfectly obvious by now that segments do not exist outside the human mind." [Hammarberg 1976]
- "No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties." [Sapir 1933]

Cudsworth's *cognoscitive* powers

In and outside of language

- "It is idle to seek a mind-independent construct that corresponds to the syllable /ba/" [Chomsky 2009:27)
- "It should be perfectly obvious by now that segments do not exist outside the human mind." [Hammarberg 1976]
- "No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties." [Sapir 1933]

Cudsworth's *cognoscitive* powers

In and outside of language

- "It is idle to seek a mind-independent construct that corresponds to the syllable /ba/" [Chomsky 2009:27)
- "It should be perfectly obvious by now that segments do not exist outside the human mind." [Hammarberg 1976]
- "No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties." [Sapir 1933]

Watch *Is the man who is tall happy?* for the Ship of Theseus and other cases.

This is you...

Stimulus independence of equivalence classes

Pylyshyn 1984

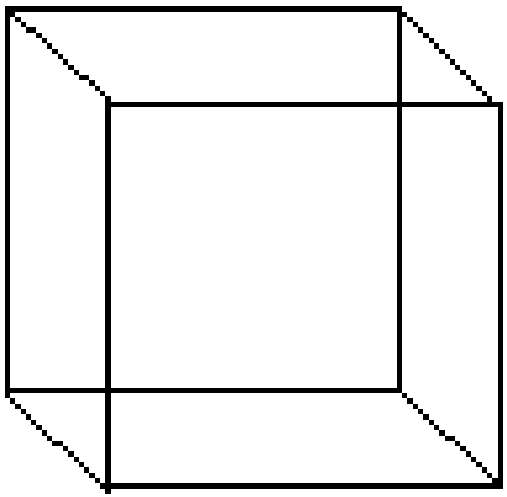
- Equivalence classes are not stimulus bound

Stimulus independence of equivalence classes

Pylyshyn 1984

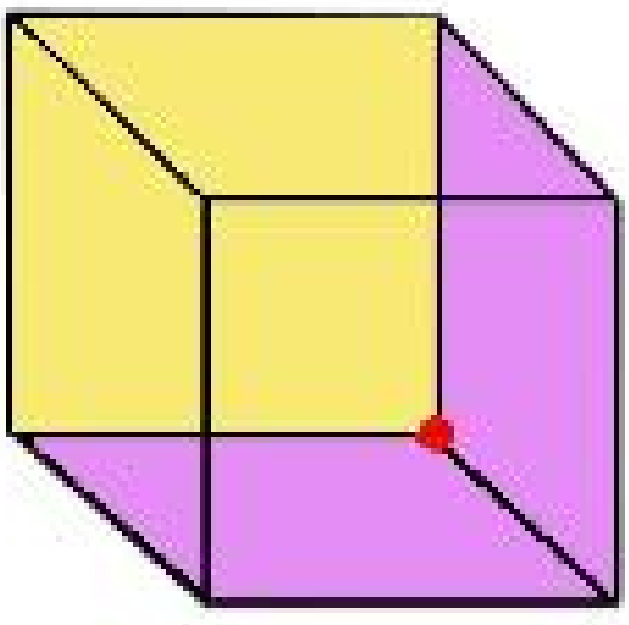
- Equivalence classes are not stimulus bound
- An infinite range of physical arrays lead to Necker Cube percept

Stimulus independence in vision—(and for language)



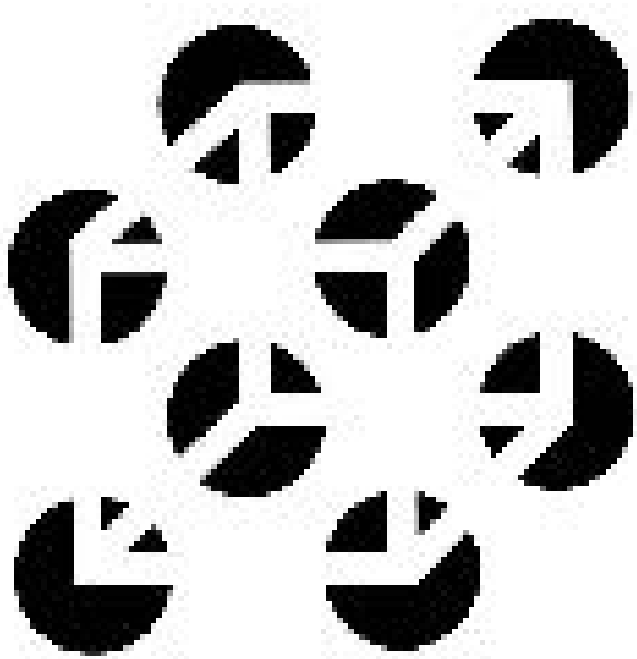
There are no necessary or sufficient **physical** conditions for the definition of a Necker cube ...

Stimulus independence in vision—(and for language)



There are no necessary or sufficient **physical** conditions for the definition of a Necker cube ...

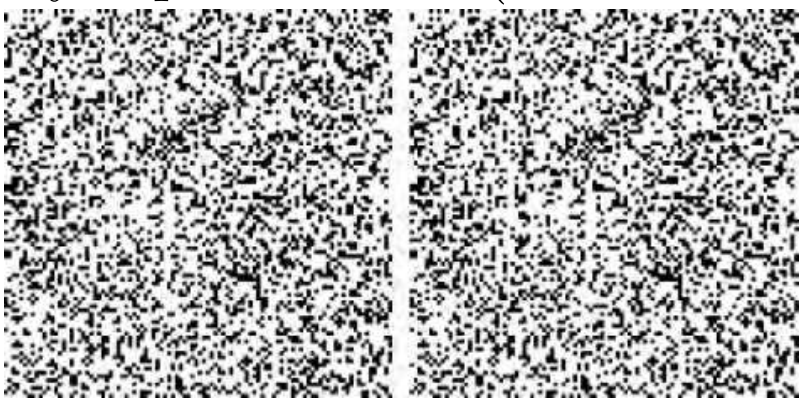
Stimulus independence in vision—(and for language)



There are no necessary or sufficient **physical** conditions for the definition of a Necker cube ...or a syllable or a /t/ or an /æ/ or an NP or a subject

Stimulus independence in vision—(and for language)

Cyclopean Vision (Julesz 1971)



There are no necessary or sufficient **physical** conditions for the definition of a Necker cube ...or a syllable or a /t/ or an /æ/ or an NP or a subject

Stimulus independence in vision—(and for language)

There are no necessary or sufficient **physical** conditions for the definition of a Necker cube ...or a syllable or a /t/ or an /æ/ or an NP or a subject

Charles using Chomsky using Cudworth to paraphrase Hammarberg

Segments are constructions of our cognoscitive powers.

Chomsky meets Scrooge[1]: [ba], humbug!

[1] *A Christmas Carol* by Charles Dickens

Chomsky meets Scrooge[1]: [ba], humbug!

Cognoscitive powers give us symbols inside language

- "No one is so deluded as to believe that there is a mind-independent object corresponding to the internal syllable [ba], some construction from motion of molecules perhaps, which is selected when I say [ba] and when you hear it" (Chomsky 2015, p.126)

[1] *A Christmas Carol* by Charles Dickens

Chomsky meets Scrooge[1]: [ba], humbug!

Cognoscitive powers give us symbols inside language

- "No one is so deluded as to believe that there is a mind-independent object corresponding to the internal syllable [ba], some construction from motion of molecules perhaps, which is selected when I say [ba] and when you hear it" (Chomsky 2015, p.126)
- "it is idle to seek a mind-independent construct that corresponds to the syllable [ba]" (Chomsky 2009, p. 27)

[1] *A Christmas Carol* by Charles Dickens

Chomsky meets Scrooge[1]: [ba], humbug!

Cognoscitive powers give us symbols inside language

- "No one is so deluded as to believe that there is a mind-independent object corresponding to the internal syllable [ba], some construction from motion of molecules perhaps, which is selected when I say [ba] and when you hear it" (Chomsky 2015, p.126)
- "it is idle to seek a mind-independent construct that corresponds to the syllable [ba]" (Chomsky 2009, p. 27)
- Of course, there are some such deluded people (see Reiss and Volenec, 2024)

[1] *A Christmas Carol* by Charles Dickens

It's not just language!

Sapir 1933 on categories of experience

- No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties.

It's not just language!

Sapir 1933 on categories of experience

- No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties.
- it is notorious how many of these physical properties are, or may be, overlooked as irrelevant

It's not just language!

Sapir 1933 on categories of experience

- No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties.
- it is notorious how many of these physical properties are, or may be, overlooked as irrelevant
- In the physical world the naive speaker and hearer actualize and are sensitive to sounds, but what they feel themselves to be pronouncing and hearing are 'phonemes'

It's not just language!

Sapir 1933 on categories of experience

- No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties.
- it is notorious how many of these physical properties are, or may be, overlooked as irrelevant
- In the physical world the naive speaker and hearer actualize and are sensitive to sounds, but what they feel themselves to be pronouncing and hearing are 'phonemes'
- sounds do not differ as five-inch and six-inch entities, but as clubs and poles differ. the phonetician can set up something "halfway" but a speaker-hearer does not

It's not just language!

Sapir 1933 on categories of experience

- No entity in human experience can be adequately defined as the mechanical sum or product of its physical properties.
- it is notorious how many of these physical properties are, or may be, overlooked as irrelevant
- In the physical world the naive speaker and hearer actualize and are sensitive to sounds, but what they feel themselves to be pronouncing and hearing are 'phonemes'
- sounds do not differ as five-inch and six-inch entities, but as clubs and poles differ. the phonetician can set up something "halfway" but a speaker-hearer does not
- we can never set up a scale of of added or changed meanings that is simply congruent to the scale of physical increments

Time for t

How many ts?

That cat, Atom, didn't want to stare at the two thin rats at ease atop the atomic pot.

Time for t

How many ts?

That cat, Atom, didn't want to stare at the two thin rats at ease atop the atomic pot.

Lessons from t

'Construction of Experience' close to home

- Things that are different physically judged as the same

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [t^{h}] *top*

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [t^{h}] *top*
    - [ʔ] *mat*

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*
- Things that are physically the same judged as different:

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*
- Things that are physically the same judged as different:
  - /t/: *wetting* ⇝ [wɛɾɪŋ]

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*
- Things that are physically the same judged as different:
  - /t/: *wetting* ⇝ [wɛɾɪŋ]
  - /d/: *wedding* ⇝ [wɛɾɪŋ]

Lessons from *t*

'Construction of Experience' close to home

- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*
- Things that are physically the same judged as different:
  - /t/: *wetting* ⇝ [wɛɾɪŋ]
  - /d/: *wedding* ⇝ [wɛɾɪŋ]

Lessons from *t*

'Construction of Experience' close to home

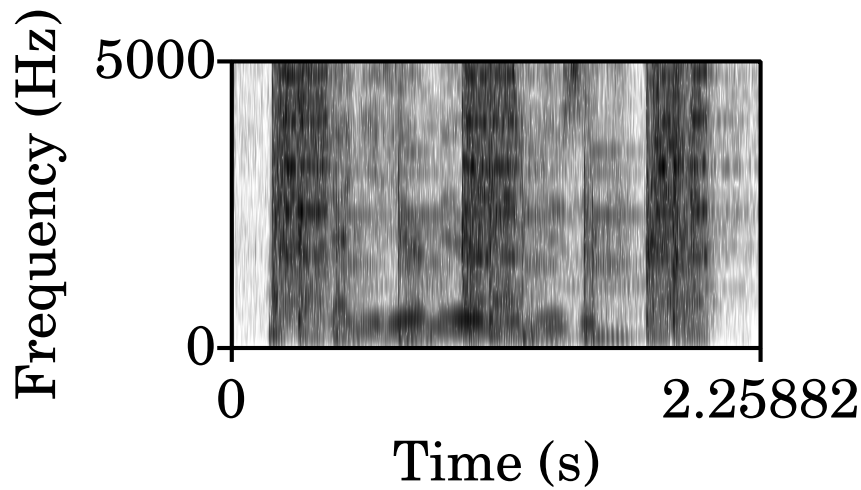
- Things that are different physically judged as the same
  - Realizations of English /t/:
    - [t] *mats*
    - [tʰ] *top*
    - [ʔ] *mat*
    - [ɾ] *fighter*
    - ∅ *left town*
- Things that are physically the same judged as different:
  - /t/: *wetting* ⇝ [wɛɾɪŋ]
  - /d/: *wedding* ⇝ [wɛɾɪŋ]

Conclusion: Perception and judgment can't be derived from the signal in any straightforward way: PoS.

Outline

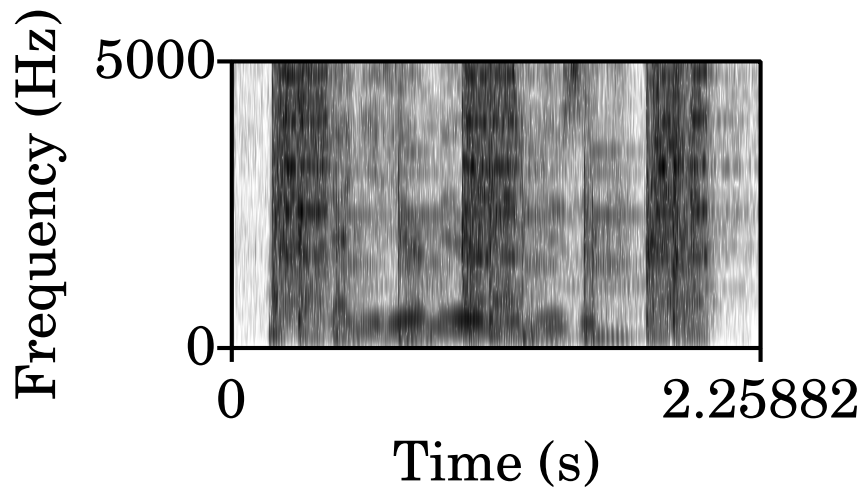
Two main problems for auditory scene analysis (Bregman 1990)

- Spectral integration and segregation within a temporal window.



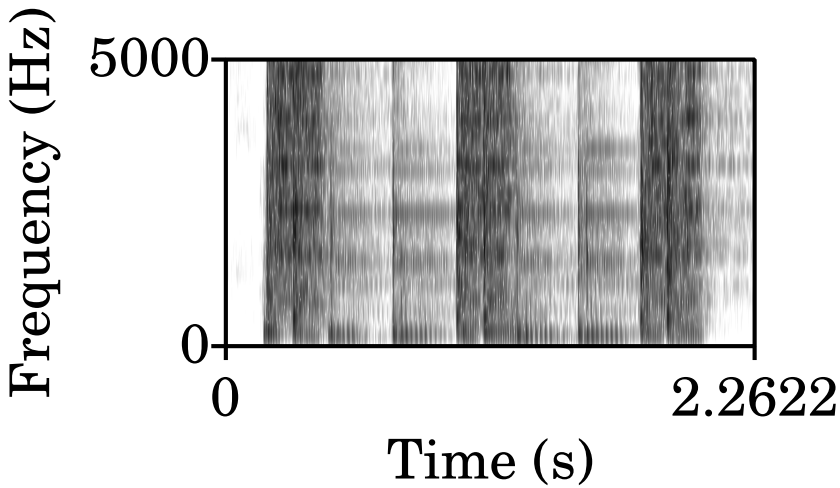
Two main problems for auditory scene analysis (Bregman 1990)

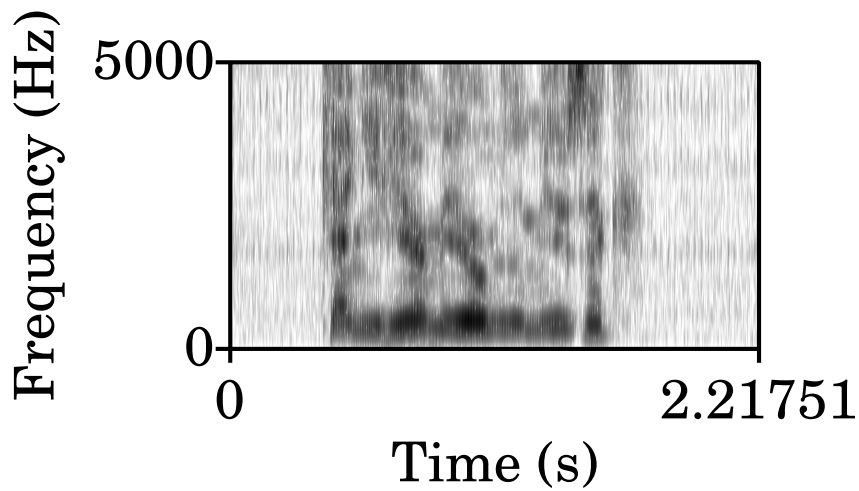
- Spectral integration and segregation within a temporal window.
- Sequential integration and segregation—acoustic events occurring separated in time may be integrated into a single auditory stream. Examples of streams include a sequence of footsteps or the continuous sound of falling rain.



A simulation

Music and speech separated into two streams.





Streaming in speech and non-speech

- Streams may be based on pitch, quality, loudness
- A loop like WHISTLE TONE VOWEL BUZZ yields four streams

WHISTLE	...	WHISTLE	...
TONE	...	TONE	...
VOWEL	...	VOWEL	...
BUZZ	...	BUZZ	...

- Speech, however, is easily streamed

A Simple Grammar for ASA (Nakajima 1996)

Streams contain events and events contain subevents, which are symbols:

- Onset (denoted by <): A steep rise of sound intensity within a certain frequency range (e.g., a critical band) can be a clue of an onset.

A Simple Grammar for ASA (Nakajima 1996)

Streams contain events and events contain subevents, which are symbols:

- Termination (denoted by >): A steep fall of sound intensity within a certain frequency range can be a clue of a termination.

A Simple Grammar for ASA (Nakajima 1996)

Streams contain events and events contain subevents, which are symbols:

- Filling (denoted by —): A piece of sound energy extending for a certain duration without any sudden change of frequency range can be a clue of a filling.

A Simple Grammar for ASA (Nakajima 1996)

Streams contain events and events contain subevents, which are symbols:

- Onset (denoted by <): A steep rise of sound intensity within a certain frequency range (e.g., a critical band) can be a clue of an onset.
- Termination (denoted by >): A steep fall of sound intensity within a certain frequency range can be a clue of a termination.
- Filling (denoted by —): A piece of sound energy extending for a certain duration without any sudden change of frequency range can be a clue of a filling.

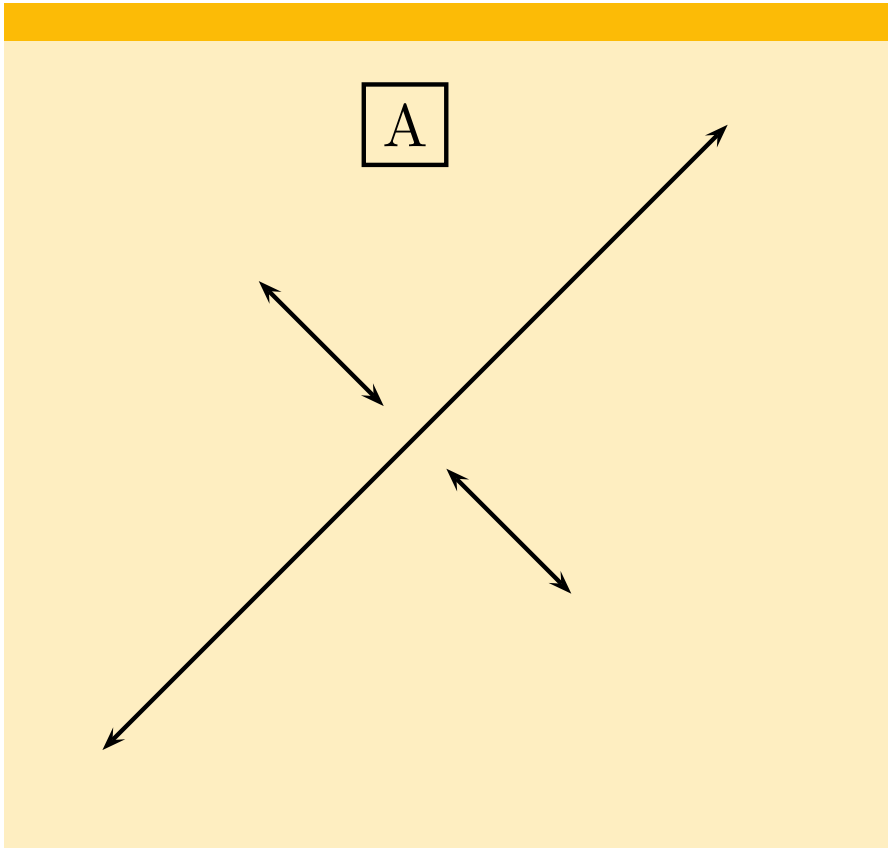
Simplifying assumptions for this presentation

- Every onset must be paired with a termination

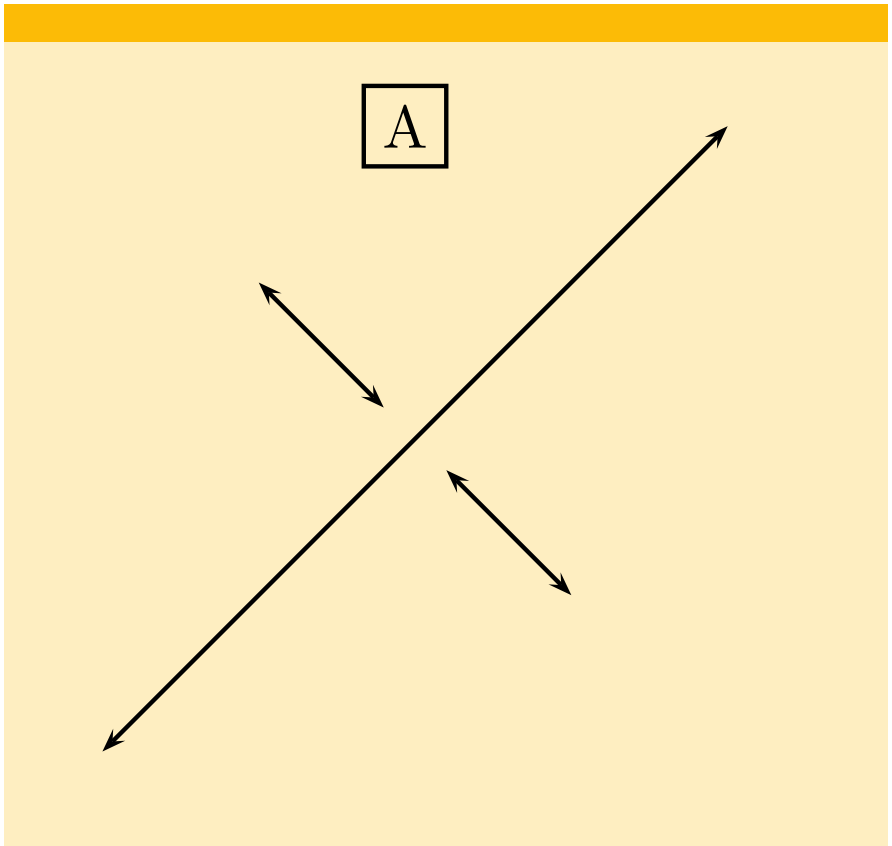
Simplifying assumptions for this presentation

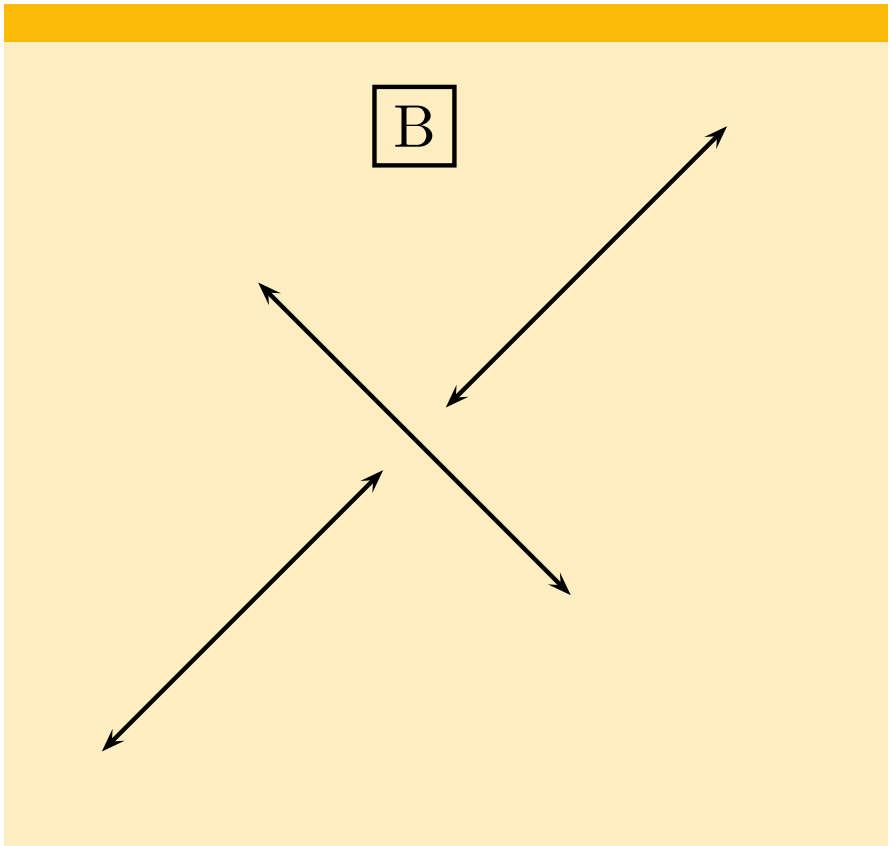
- Every onset must be paired with a termination
- Onsets and terminations may be inserted and deleted and associated with each other (non-veridically)

Gap transfer illusion



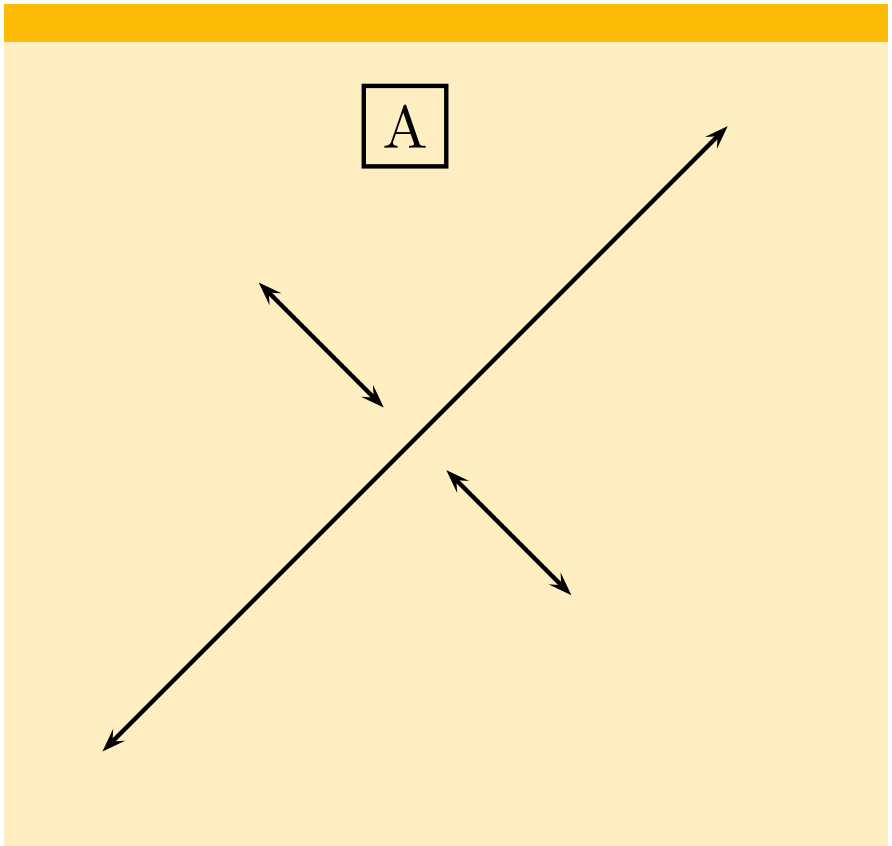
Gap transfer illusion

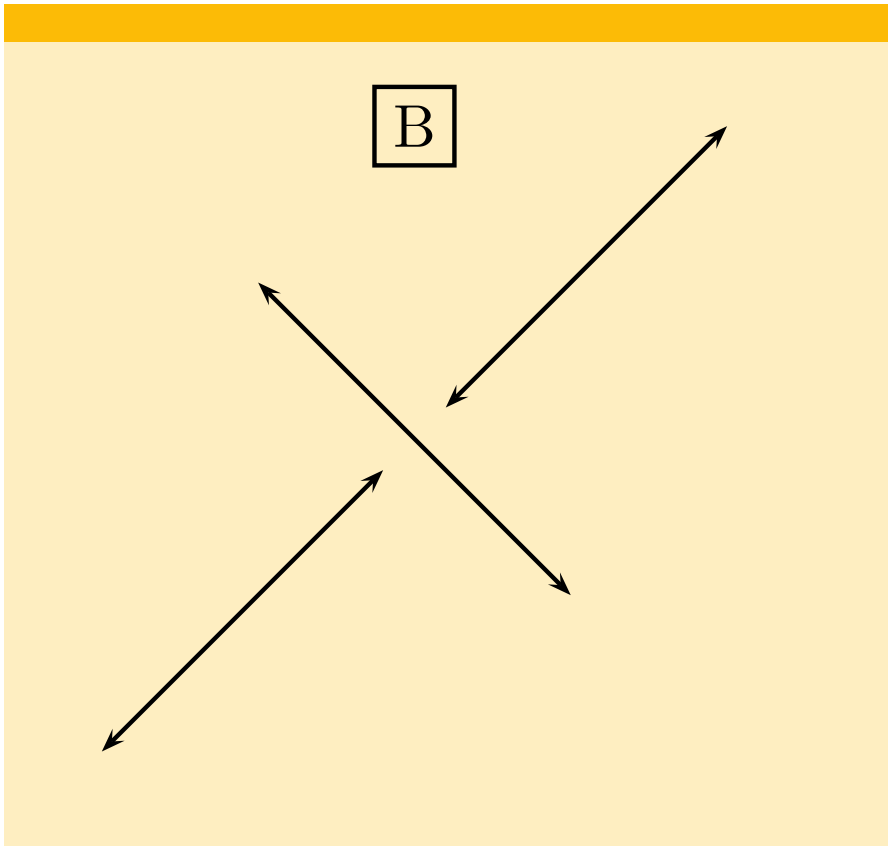




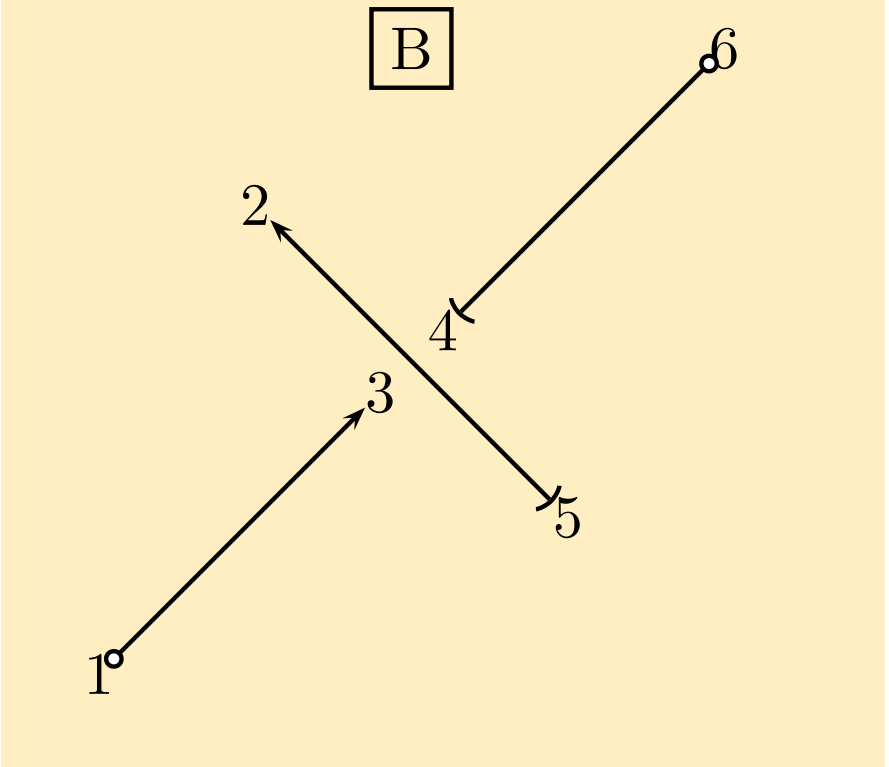
Gap transfer illusion

B perceived as A

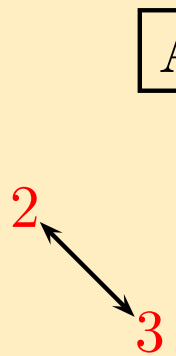


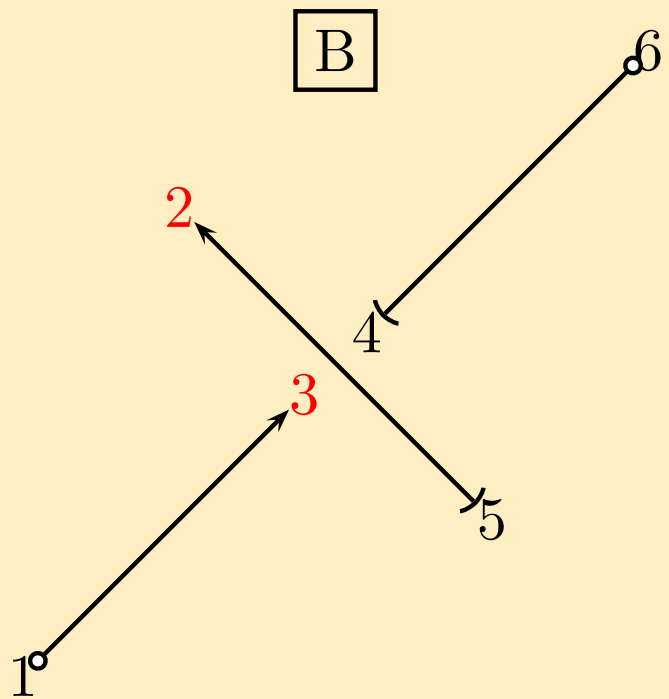


Boundary reassociation

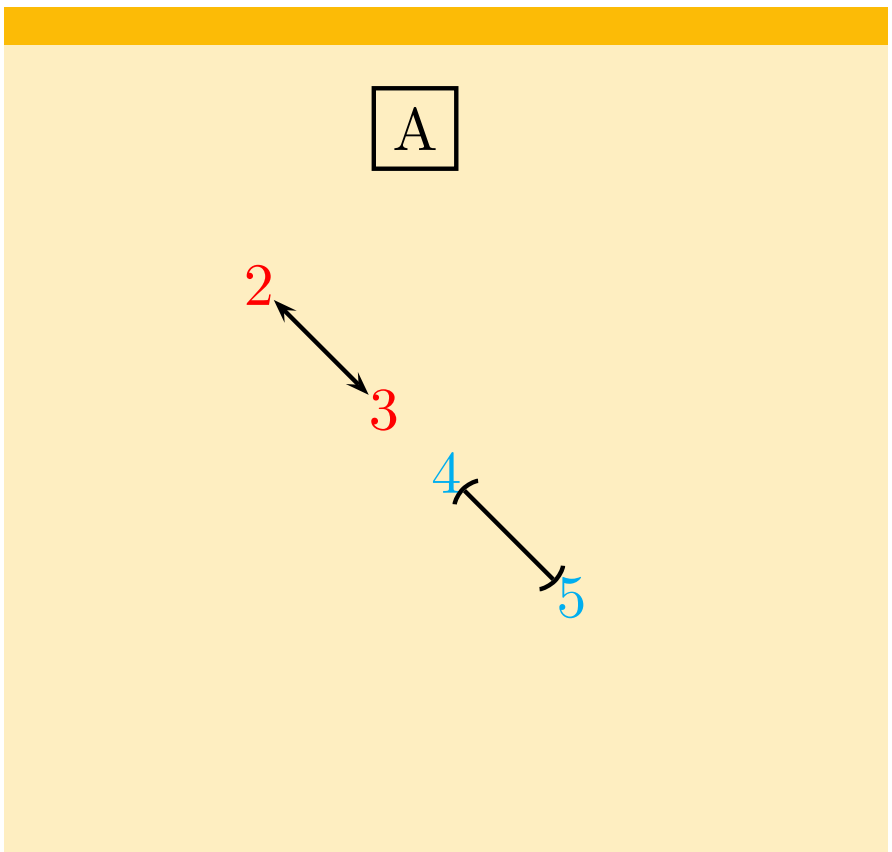


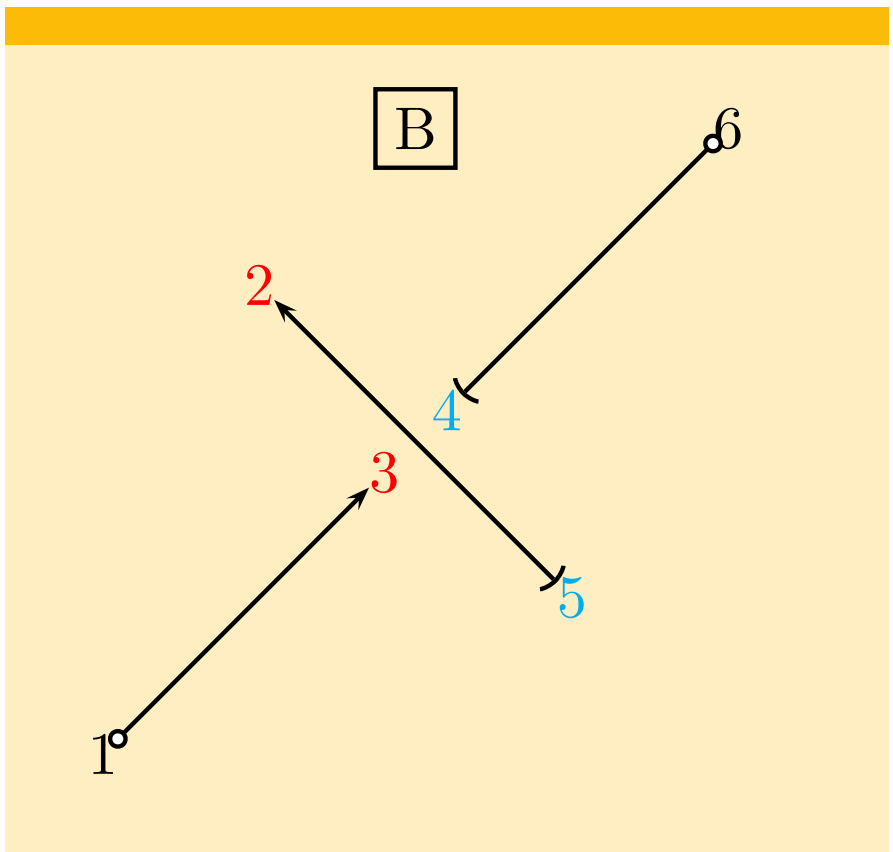
Boundary reassociation



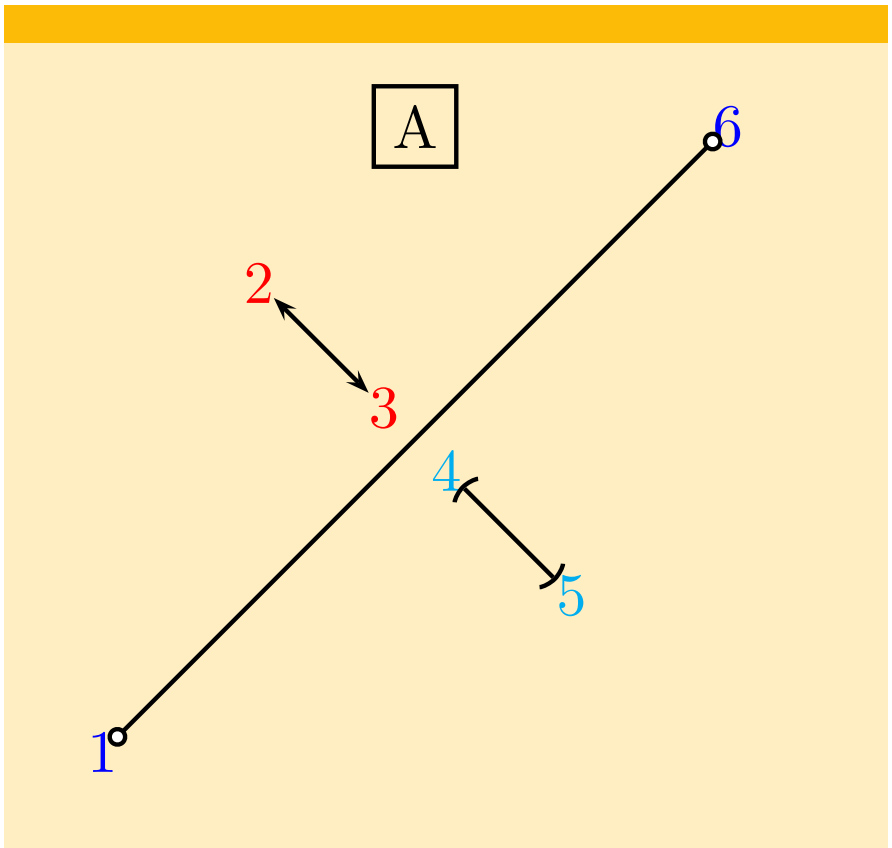


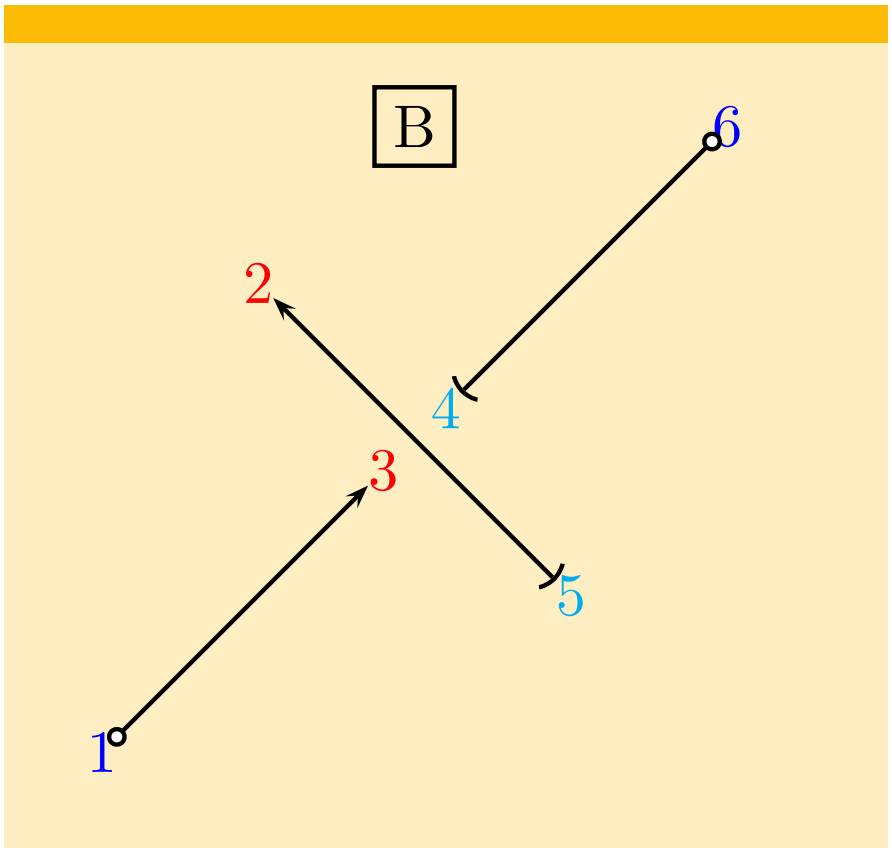
Boundary reassociation





Boundary reassociation





Signal

$<_{a1}$ $<_{b2}$ $>_{a3}$ $<_{c4}$ $>_{b5}$ $>_{c6}$

Signal

$<_{a1}$ $<_{b2}$ $>_{a3}$ $<_{c4}$ $>_{b5}$ $>_{c6}$

Percept (after reassociation of boundaries)

$<_{\alpha 1}$ $<_{\beta 2}$ $>_{\beta 3}$ $<_{\gamma 4}$ $>_{\gamma 5}$ $>_{\alpha 6}$

Immediate constituent analysis of streams

a. $[_x$ $]_x$ $[_y$ $]_y$ sequential–Possible

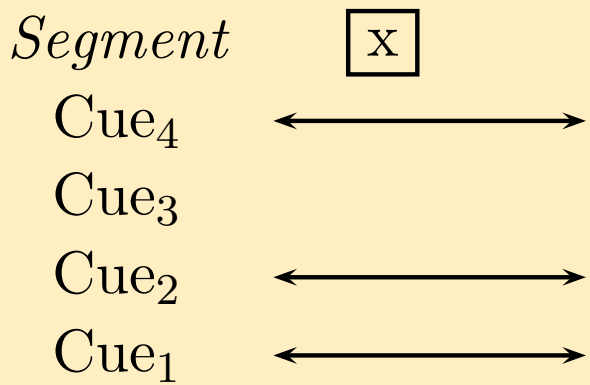
Immediate constituent analysis of streams

a.	$[_x$	$]_x$	$[_y$	$]_y$	sequential–Possible
b.	$[_x$	$[_y$	$]_y$	$]_x$	embedded–Possible

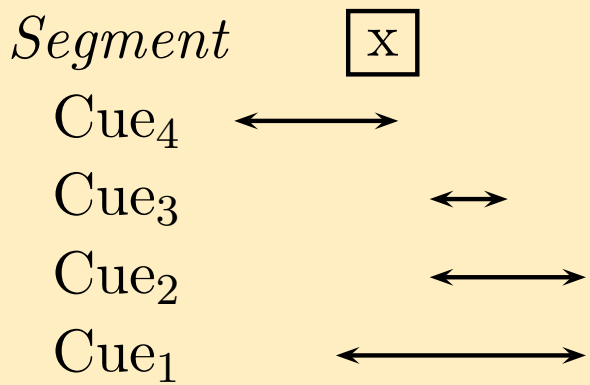
Immediate constituent analysis of streams

a.	$[_x$	$]_x$	$[_y$	$]_y$	sequential–Possible
b.	$[_x$	$[_y$	$]_y$	$]_x$	embedded–Possible
c.	$[_x$	$[_y$	$]_x$	$]_y$	interlocked–Not Possible

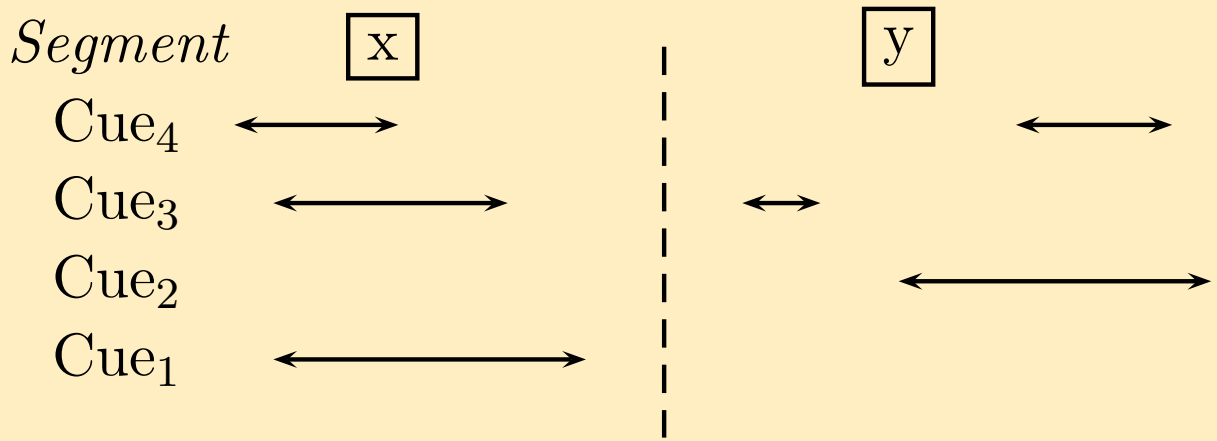
Idealized segment



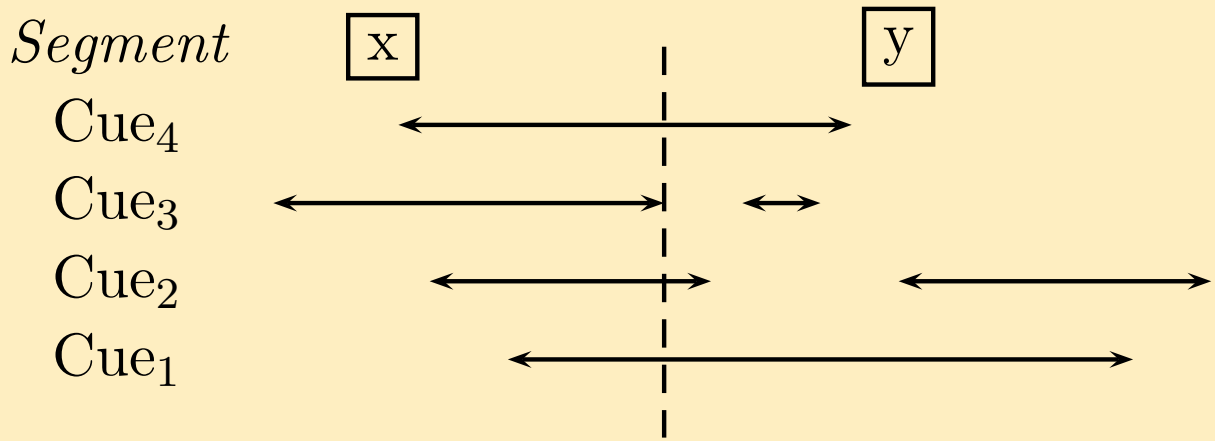
Acoustic cue / articulatory gesture alignment



Idealized alignment of cues / gestures

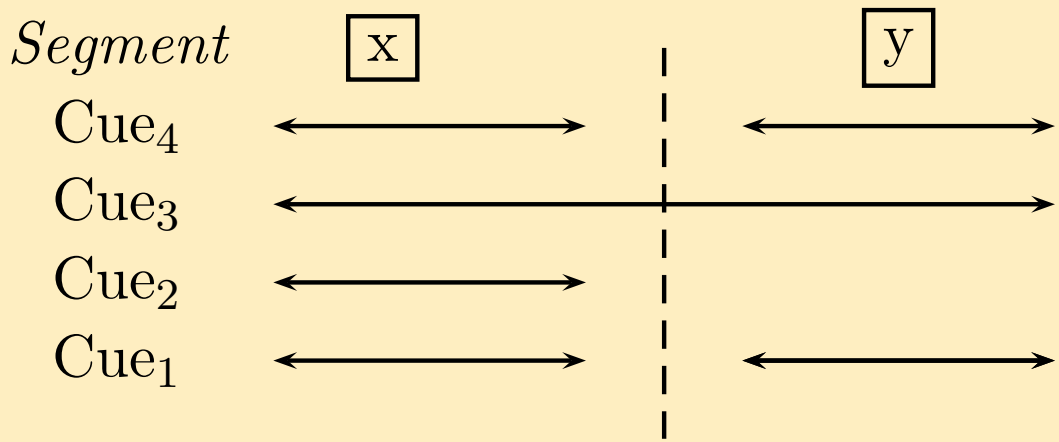


Physical alignment of cues / gestures



Despite the complex temporal relation among cues both within and across segment boundaries, I suggest that the equivalence classes generated in speech perception lead to a representation more like this, where I have (simplistically) equated cues with features.

Claim: (Quasi-)Phonological representation



- Audition

- Audition
  - a transduction that constructs subevents

- Audition
  - a transduction that constructs subevents
  - a symbolic computation that infers events

- Audition
  - a transduction that constructs subevents
  - a symbolic computation that infers events
- Symbolic computation also found in syntax, morphology, vision

- Audition
  - a transduction that constructs subevents
  - a symbolic computation that infers events
- Symbolic computation also found in syntax, morphology, vision
- Phonology

- Audition
  - a transduction that constructs subevents
  - a symbolic computation that infers events
- Symbolic computation also found in syntax, morphology, vision
- Phonology
  - a (set of) transductions that construct representations (feature bundles, *etc.*). These are fed by audition

- Audition
  - a transduction that constructs subevents
  - a symbolic computation that infers events
- Symbolic computation also found in syntax, morphology, vision
- Phonology
  - a (set of) transductions that construct representations (feature bundles, *etc.*). These are fed by audition
  - symbolic computations—phonological rules

Three potential uses of this demonstration (1)

Support for symbolic computation

Given the evidence for symbol processing in audition and morphology and syntax, it is tempting to assume that phonology works that way, too.

Three potential uses of this demonstration (2)

Hypothesis 1

Speech perception involves the construction of streams that inherit the immediate constituent structure of auditory perception. Thus, the segment 'inherits' structure from audition.

Three potential uses of this demonstration (3)

Hypothesis 2

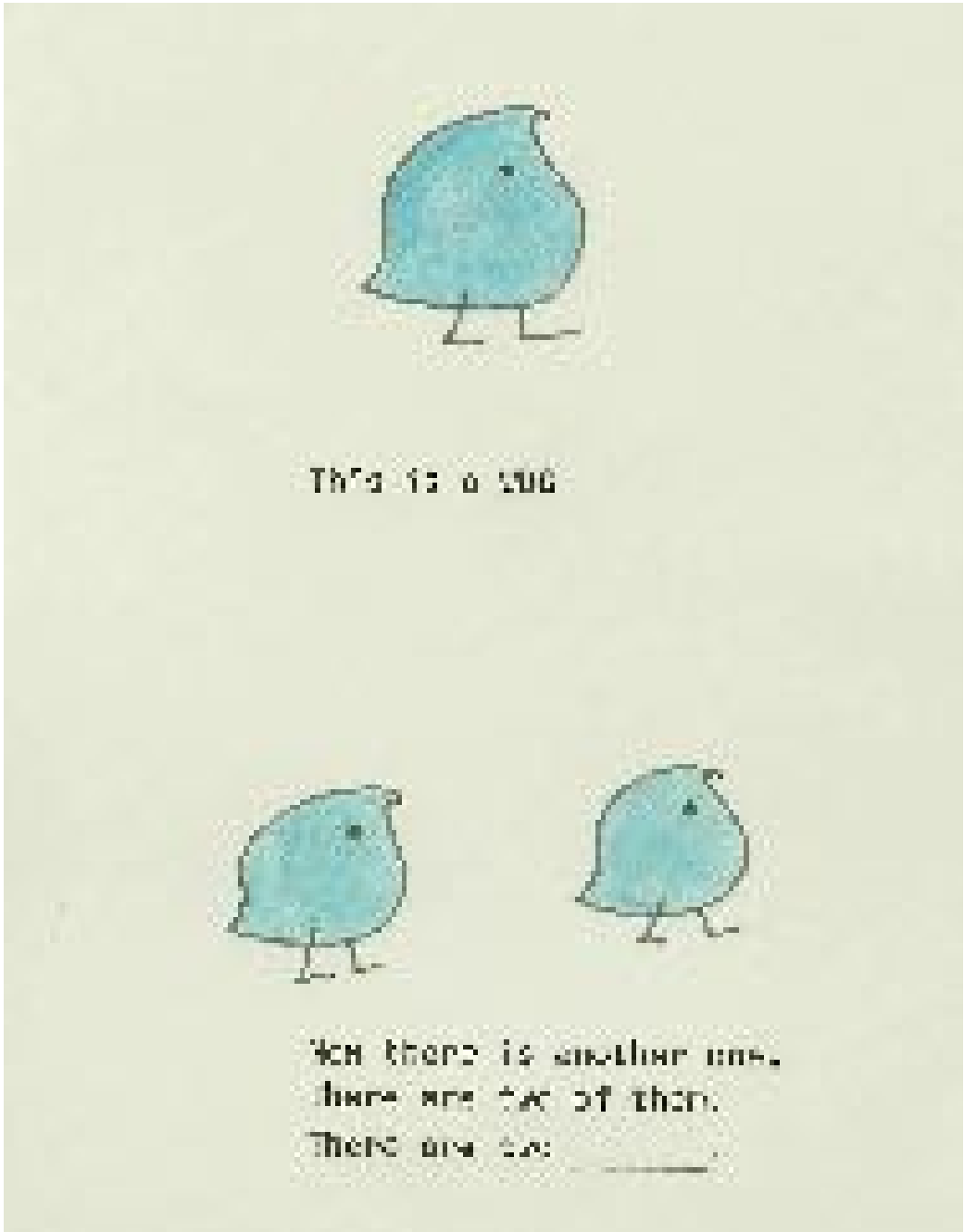
The kinds of computations we see in the Gap Transfer Illusion can ultimately explain diachronically common phonological patterns as well.
For example, long duration cues undergo more changes because the possibilities of reassociation are greater.

Outline

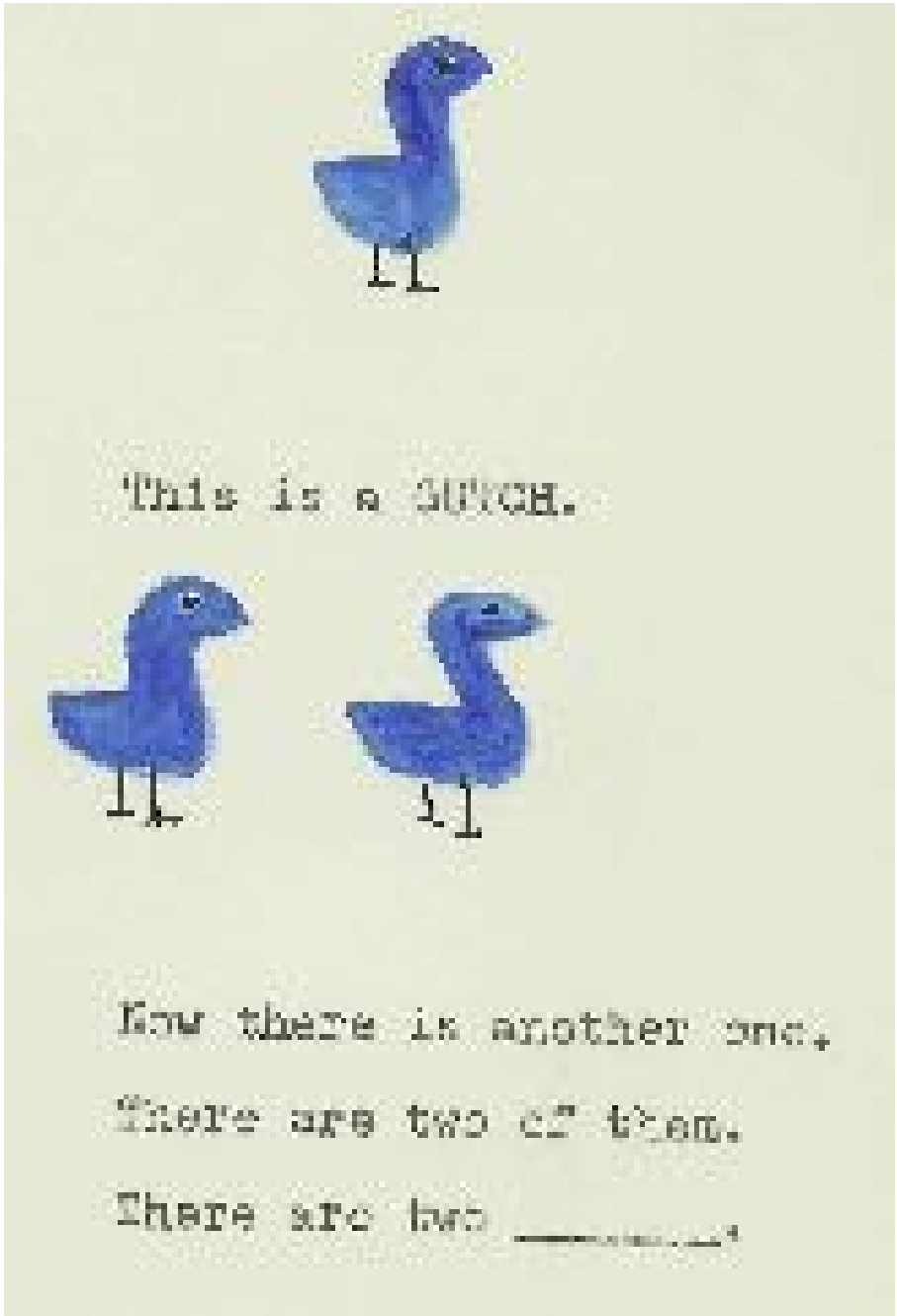
Finally back to rules...

Finally back to rules...

The *wug*-test (Berko(-Gleason)), 1958)



The *wug*-test (Berko(-Gleason), 1958)



The *wug*-test

Berko wanted to see if the plural sound was memorized or if there was a rule to compute it, so she used fake words.

Kylian Dabbous-Beguel, 2022

English regular plural forms

- *wugs* [wəg-z]
- *gutches* [gət$^{\int}$-ɨz]
- *wucks* [wək-s]

Outline

English regular plural

a. [-s]	b. [-z]	c.[-ɨz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	match
cliff	hive	whiz
myth	bow, bee, clue	garage
	pickle, burger	judge

Wug test

a. [-s]	b. [-z]	c.[-ɪz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	match
cliff	hive	whiz
myth	bow, bee, clue	garage
wuck	pickle, burger	judge
shope	wug	wutch
	scrad	biss

Wug test

a. [-s]	b. [-z]	c.[-ɪz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	match
cliff	hive	whiz
myth	bow, bee, clue	garage
wuck	pickle, burger	judge
shope	wug	wutch
	scrad	biss

Plurals are not learned word-by-word.

Which segments take [-s]?

- Segment are sets of (valued) features

Which segments take [-s]?

- Segment are sets of (valued) features
- Rules are built on natural classes

Which segments take [-s]?

- Segment are sets of (valued) features
- Rules are built on natural classes
- Natural classes are sets of segments

Which segments take [-s]?

- Segment are sets of (valued) features
- Rules are built on natural classes
- Natural classes are sets of segments
  - (set of sets of valued features)

Which segments take [-s]?

- Segment are sets of (valued) features
- Rules are built on natural classes
- Natural classes are sets of segments
  - (set of sets of valued features)
- Natural classes are defined by generalized intersections

$$\bigcap \left\{ \begin{array}{ccccc} \text{p} & \text{t} & \text{k} & \text{f} & \theta \\ \left\{ \begin{array}{l} -\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ +\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array} \right\}, & \left\{ \begin{array}{l} +\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array} \right\}, & \left\{ \begin{array}{l} -\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Con} \\ -\textsc{Ant} \\ -\textsc{Voi} \end{array} \right\}, & \left\{ \begin{array}{l} -\textsc{Cor} \\ +\textsc{Strid} \\ -\textsc{Nas} \\ +\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ +\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array} \right\}, & \left\{ \begin{array}{l} +\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ +\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array} \right\} \end{array} \right\}$$

Formation of natural class via generalized intersection

$$\bigcap \{\text{p, t, k, f, } \theta\} = \left\{ \begin{array}{l} - \textsc{Nas} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ - \textsc{Voi} \end{array} \right\}$$

Natural class expressed intensionally (superset version)

$$\left\{ y : y \supseteq \left\{ \begin{array}{l} - \textsc{Nas} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ - \textsc{Voi} \end{array} \right\} \right\}$$

Natural class expressed intensionally (subset version)

$$\left\{ y : \left\{ \begin{array}{l} - \textsc{Nas} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ - \textsc{Voi} \end{array} \right\} \subseteq y \right\}$$

Natural class and subsets

$$\left\{\begin{array}{l} -\textsc{Nas} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Voi} \end{array}\right\} \subseteq \left\{\begin{array}{l} \text{p} \\ -\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ +\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array}\right\}$$

Natural class and subsets

t

$$\left\{\begin{array}{l} -\textsc{Nas} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Voi} \end{array}\right\} \subseteq \left\{\begin{array}{l} +\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array}\right\}$$

Natural class and subsets

k

$$\left\{\begin{array}{l}-\textsc{Nas}\\-\textsc{Son}\\-\textsc{Lat}\\-\textsc{Del}\\-\textsc{Voi}\end{array}\right\} \subseteq \left\{\begin{array}{l}-\textsc{Cor}\\-\textsc{Strid}\\-\textsc{Nas}\\-\textsc{Lab}\\-\textsc{Son}\\-\textsc{Lat}\\-\textsc{Del}\\-\textsc{Con}\\+\textsc{Ant}\\-\textsc{Voi}\end{array}\right\}$$

Natural class and subsets

$$\left\{\begin{array}{l} - \textsc{Nas} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ - \textsc{Voi} \end{array}\right\} \subseteq \overset{\text{f}}{\left\{\begin{array}{l} - \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ + \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{array}\right\}}$$

Natural class and subsets

$$\left\{\begin{array}{l} -\textsc{Nas} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Voi} \end{array}\right\} \subseteq \overset{\theta}{\left\{\begin{array}{l} +\textsc{Cor} \\ +\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ +\textsc{Con} \\ +\textsc{Ant} \\ -\textsc{Voi} \end{array}\right\}}$$

A ‘new’ segment

$$\left\{\begin{array}{l} -\textsc{Nas} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Voi} \end{array}\right\} \subseteq$$

A ‘new’ segment

x

$$\left\{\begin{array}{l} -\textsc{Nas} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ -\textsc{Voi} \end{array}\right\} \subseteq \left\{\begin{array}{l} -\textsc{Cor} \\ -\textsc{Strid} \\ -\textsc{Nas} \\ -\textsc{Lab} \\ -\textsc{Son} \\ -\textsc{Lat} \\ -\textsc{Del} \\ +\textsc{Con} \\ -\textsc{Ant} \\ -\textsc{Voi} \end{array}\right\}$$

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger
  - Can't help but say/accept [baxs], despite the lack of exposure to [x]

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger
  - Can't help but say/accept [baxs], despite the lack of exposure to [x]
  - This is not '(over)generalization', it is just what it means to have a rule.

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger
  - Can't help but say/accept [baxs], despite the lack of exposure to [x]
  - This is not '(over)generalization', it is just what it means to have a rule.
  - Is this PoS?

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger
  - Can't help but say/accept [baxs], despite the lack of exposure to [x]
  - This is not '(over)generalization', it is just what it means to have a rule.
  - Is this PoS?
  - (Menn and Halle have an implicit theory of what is acquired, in contrast with, e.g. Mielke)

Lise Menn / Morris Halle's example: *Bachs*

What happens with a new segment /x/

- Rules are defined *intensionally*, via natural classes
- Circumstances change—(let's say) you get /x/ in *Bach*
- So /x/ is *necessarily* (by set theory) a trigger of any rule that /p,t,k,f,θ/ all trigger
  - Can't help but say/accept [baxs], despite the lack of exposure to [x]
  - This is not '(over)generalization', it is just what it means to have a rule.
  - Is this PoS?
  - (Menn and Halle have an implicit theory of what is acquired, in contrast with, e.g. Mielke)
  - (What if there is *not* just one rule?)

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS
  - Set up one rule for all triggering segments

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS
  - Set up one rule for all triggering segments
- If s/he could have separate rules, then it would be possible to *not generalize* to [x]

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS
  - Set up one rule for all triggering segments
- If s/he could have separate rules, then it would be possible to *not generalize* to [x]
- Epistemic boundedness: Learner is incapable of having separate rules if the data is consistent with a single rule

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS
  - Set up one rule for all triggering segments
- If s/he could have separate rules, then it would be possible to *not generalize* to [x]
- Epistemic boundedness: Learner is incapable of having separate rules if the data is consistent with a single rule
- Our scope/limits prevent us from *not* devoicing after [x]

Think negative

What the learner *can't* do

- Given the stimulus, there are several extensionally equivalent grammars, e.g.
  - Set up separate rules for each triggering segment VERSUS
  - Set up one rule for all triggering segments
- If s/he could have separate rules, then it would be possible to *not generalize* to [x]
- Epistemic boundedness: Learner is incapable of having separate rules if the data is consistent with a single rule
- Our scope/limits prevent us from *not* devoicing after [x]
- Doing so is beyond the limits of UG—humans are incapable of *not* using natural classes

Outline

Do we really need to rely on *Bachs*?

English nouns with each alternant of the regular plural suffix

a. [-s]	b. [-z]	c.[-ɪz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	match
cliff	hive	whiz
myth	bow, bee, clue	garage
	pickle, burger	judge
		natural class
		coronal stridents

Alternants of the regular plural suffix /-z/

a. [-s]	b. [-z]	c.[-ɨz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	match
cliff	hive	whiz
myth	bow, bee, clue	garage
	pickle, burger	judge
	not natural class	natural class:
	ELSEWHERE case	coronal stridents

Alternants of the regular plural suffix /-z/

a. [-s]	b. [-z]	c.[-ɨz]
cup	cub, head, rug	bus
mat	farm, son, song	bush
rack	car, hill	mass
cliff	hive	whiz
myth	bow, bee, clue	garage
	pickle, burger	judge
not a natural class	not natural class	natural class
	ELSEWHERE case	coronal stridents

$$\bigcap\{\text{s}, \text{ʃ}, \text{t}^{\text{ʃ}}, \text{z}, \text{ʒ}, \text{d}^{\text{ʒ}}\} =$$

$$\bigcap \left\{ \begin{matrix} \text{s} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{matrix}\right\} \end{matrix}, \begin{matrix} \text{ʃ} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ - \textsc{Ant} \\ - \textsc{Voi} \end{matrix}\right\} \end{matrix}, \begin{matrix} \text{t}^{\text{ʃ}} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ + \textsc{Del} \\ - \textsc{Con} \\ - \textsc{Ant} \\ - \textsc{Voi} \end{matrix}\right\} \end{matrix}, \begin{matrix} \text{z} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ + \textsc{Voi} \end{matrix}\right\} \end{matrix}, \begin{matrix} \text{ʒ} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ - \textsc{Ant} \\ + \textsc{Voi} \end{matrix}\right\} \end{matrix}, \begin{matrix} \text{d}^{\text{ʒ}} \\ \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ + \textsc{Del} \\ - \textsc{Con} \\ - \textsc{Ant} \\ + \textsc{Voi} \end{matrix}\right\} \end{matrix} \right\}$$

$$= \text{Let's say } \left\{\begin{matrix} + \textsc{Cor} \\ + \textsc{Strid} \\ (\ldots) \end{matrix}\right\}$$

Consider /s/ (and /ʃ/)

$$s = \left\{ \begin{array}{l} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{array} \right\}$$

Obviously /s/ is relevant to any rule that refers to {s, ʃ, $t^{ʃ}$, z, ʒ, $d^{ʒ}$}

Consider /s/ (and /ʃ/)

$$s = \left\{ \begin{array}{l} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{array} \right\} \supseteq = \left\{ \begin{array}{l} + \textsc{Cor} \\ + \textsc{Strid} \end{array} \right\}$$

Obviously /s/ is relevant to any rule that refers to {s, ʃ, $t^{ʃ}$, z, ʒ, $d^{ʒ}$}

Consider /s/ (and /ʃ/)

$$s = \left\{ \begin{array}{l} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{array} \right\}$$

But /s/ is (also) necessarily relevant to any rule that refers to {p,t,k,f,θ} (and x)

Consider /s/ (and /ʃ/)

$$\text{s} = \left\{ \begin{array}{l} + \textsc{Cor} \\ + \textsc{Strid} \\ - \textsc{Nas} \\ - \textsc{Lab} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ + \textsc{Con} \\ + \textsc{Ant} \\ - \textsc{Voi} \end{array} \right\} \supseteq \left\{ \begin{array}{l} - \textsc{Nas} \\ - \textsc{Son} \\ - \textsc{Lat} \\ - \textsc{Del} \\ - \textsc{Voi} \end{array} \right\}$$

But /s/ is (also) necessarily relevant to any rule that refers to {p,t,k,f,θ} (and x)

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- First insert a vowel between a coronal strident and /z/

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- First insert a vowel between a coronal strident and /z/

Insertion rule: $\epsilon \mapsto$ ɨ/ $\left[\begin{array}{l} +\textsc{Cor} \\ +\textsc{Strid} \end{array}\right]$— z

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- First insert a vowel between a coronal strident and /z/

  Insertion rule: $\epsilon \mapsto$ ɨ/ $\left[\begin{array}{l} +\textsc{Cor} \\ +\textsc{Strid} \end{array} \right]$—— z

  - /mæs-z/ →/mæsɨz/

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- Then devoicing rule applies

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- Then devoicing rule applies
- Formulated INTENSIONALLY to apply after ALL voiceless segments (even s,ʃ in the absence of 'data')

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- Then devoicing rule applies
- Formulated INTENSIONALLY to apply after ALL voiceless segments (even s,ʃ in the absence of 'data')
  - Rule does not affect [z] in /mæsɨz/ since /s/ and /z/ are not adjacent

Why doesn't /s/ devoice the plural /-z/?

Bleeding rule ordering

- Then devoicing rule applies
- Formulated INTENSIONALLY to apply after ALL voiceless segments (even s,ʃ in the absence of 'data')
  - Rule does not affect [z] in /mæsɨz/ since /s/ and /z/ are not adjacent
  - Circumstances have changed! (Like Seymour's taste in letters.)

The key

Intensional rule

- Refers to whole natural class

The key

Intensional rule

- Refers to whole natural class
- Data doesn't reflect this! {p,t,k,f,θ} *not* a natural class.)

The key

Intensional rule

- Refers to whole natural class
- Data doesn't reflect this! {p,t,k,f,θ} *not* a natural class.)
  - Just as Meg told us that "red cards except for diamonds" is not a class

The key

Intensional rule

- Refers to whole natural class
- Data doesn't reflect this! {p,t,k,f,θ} *not* a natural class.)
  - Just as Meg told us that "red cards except for diamonds" is not a class
- Poverty of the Stimulus

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

- Vowel insertion between coronal stridents and -z

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

- Intensional formulation of devoicing rule targets /z/ before p,t,k,f,θ,s,ʃ
  - but the rule is bled in some forms

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

- The ‘data’ says that devoicing is not triggered by s,ʃ

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	‘mats’	‘cliffs’	‘heads’	‘bushes’	‘masses’	‘whizzes’

- Kids don’t encode the ‘patterns in the surface data’ or the ‘auditory input’

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

- Kids don't encode the 'patterns in the surface data' or the 'auditory input'
- Kids *can't* encode the 'patterns in the surface data' or the 'auditory input'

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

- Kids don't encode the 'patterns in the surface data' or the 'auditory input'
- Kids *can't* encode the 'patterns in the surface data' or the 'auditory input'
  - They can't be little empiricists—Jerry Fodor won't allow it!

English Plural Derivations

UR	/mæt-z/	/klɪf-z/	/hɛd-z/	/bʊʃ-z/	/mæs-z/	/wɪz-z/
Insert Rule	—	—	—	bʊʃɨz	mæsɨz	wɪzɨz
Devoic Rule	mæts	klɪfs	—	BLED	BLED	—
SR	[mæts]	[klɪfs]	[hɛdz]	[bʊʃɨz]	[mæsɨz]	[wɪzɨz]
Gloss	'mats'	'cliffs'	'heads'	'bushes'	'masses'	'whizzes'

- Kids don't encode the 'patterns in the surface data' or the 'auditory input'
- Kids *can't* encode the 'patterns in the surface data' or the 'auditory input'
  - They can't be little empiricists—Jerry Fodor won't allow it!
  - Epistemic boundedness strikes again!

Bleeding and Remnant movement

- Only have rules that refer to natural classes

Bleeding and Remnant movement

- Only have rules that refer to natural classes
- Only have XP movement: Move XP_1 out of XP_2, then move XP_2

Phonology/Syntax parallel

Bleeding and Remnant movement

- Only have rules that refer to natural classes
- Only have XP movement: Move XP_1 out of XP_2, then move XP_2
- Reasoning is the same—(see Reiss, 2024)

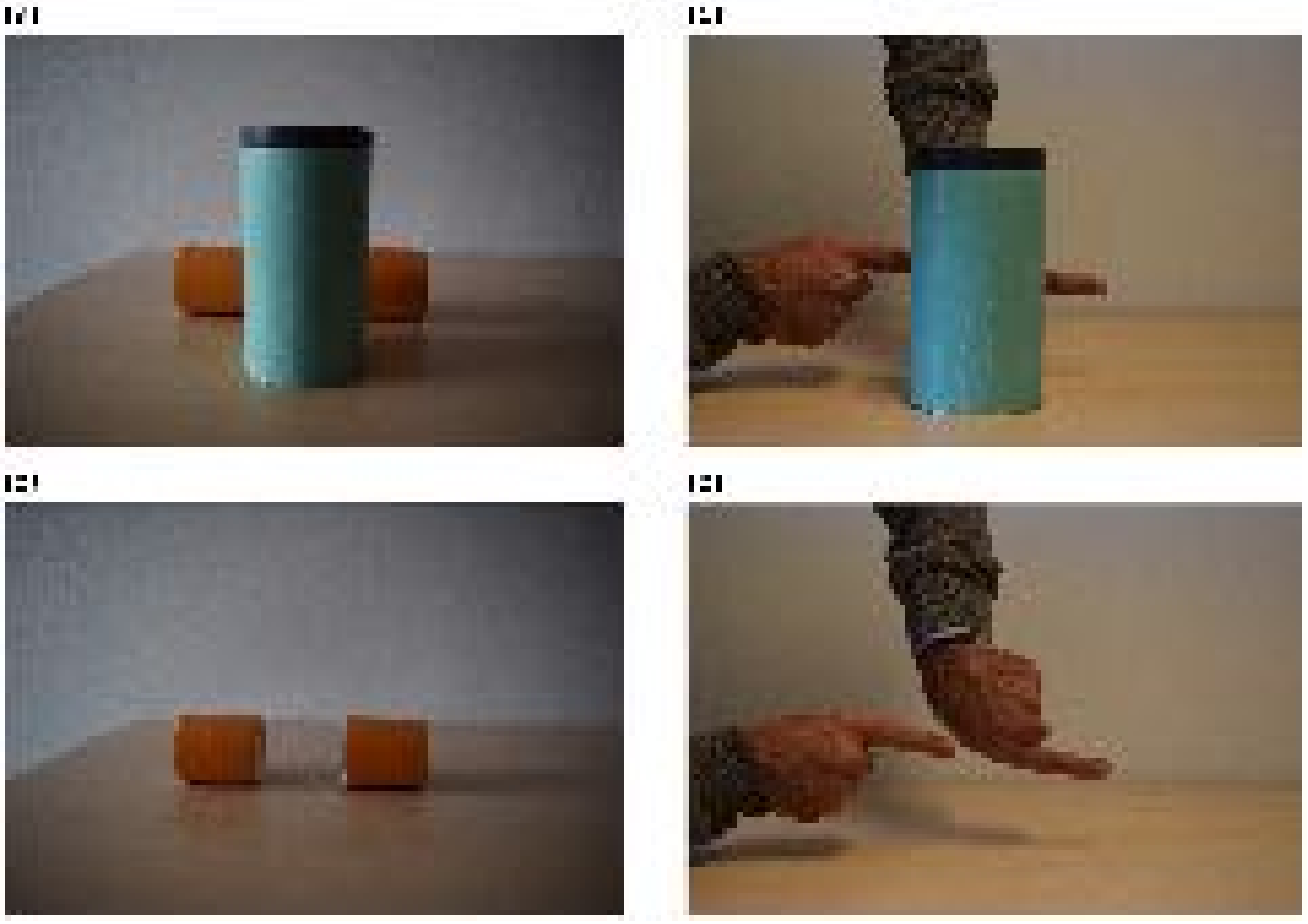
Phonology/Syntax parallel

Bleeding and Remnant movement

- Only have rules that refer to natural classes
- Only have XP movement: Move XP_1 out of XP_2, then move XP_2
- Reasoning is the same—(see Reiss, 2024)
- "As concepts and principles become simpler, argument and inference tend to become more complex—a consequence that is naturally very much to be welcomed" Chomsky (1981:3).

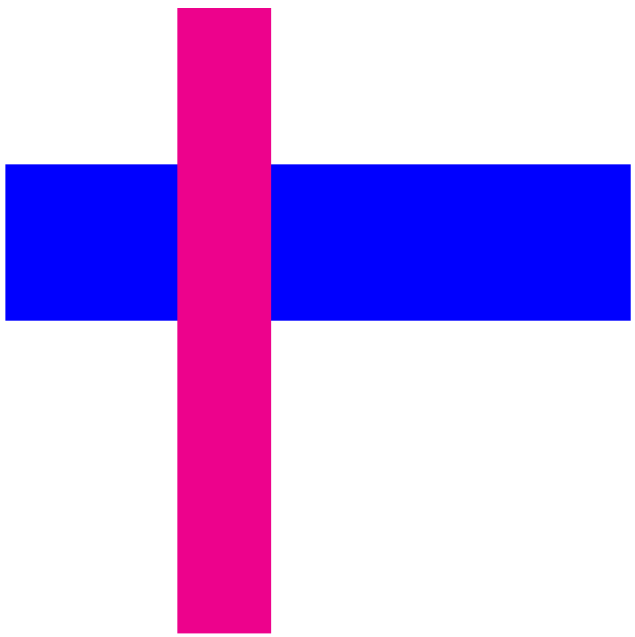
Amodal completion

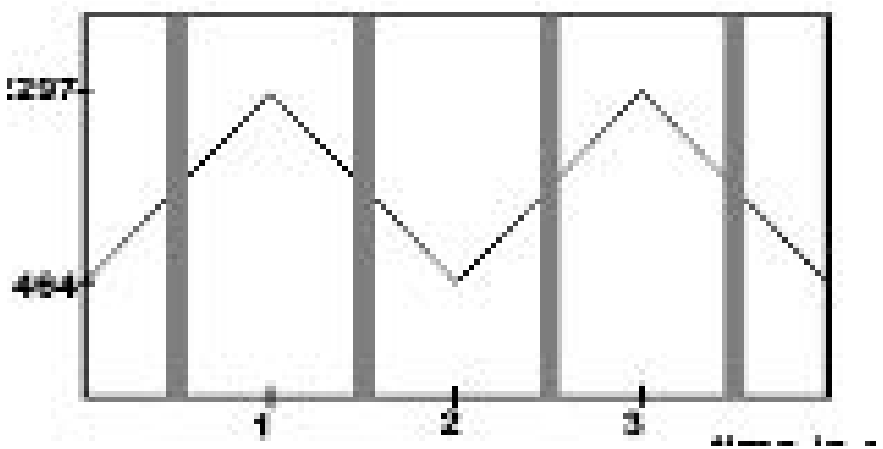
Amodal completion



Masking in vision and audition

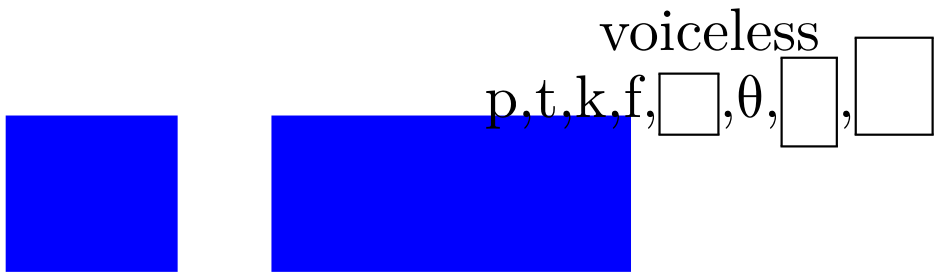
- Can't help but see two objects
- Can't help but hear continuous tone





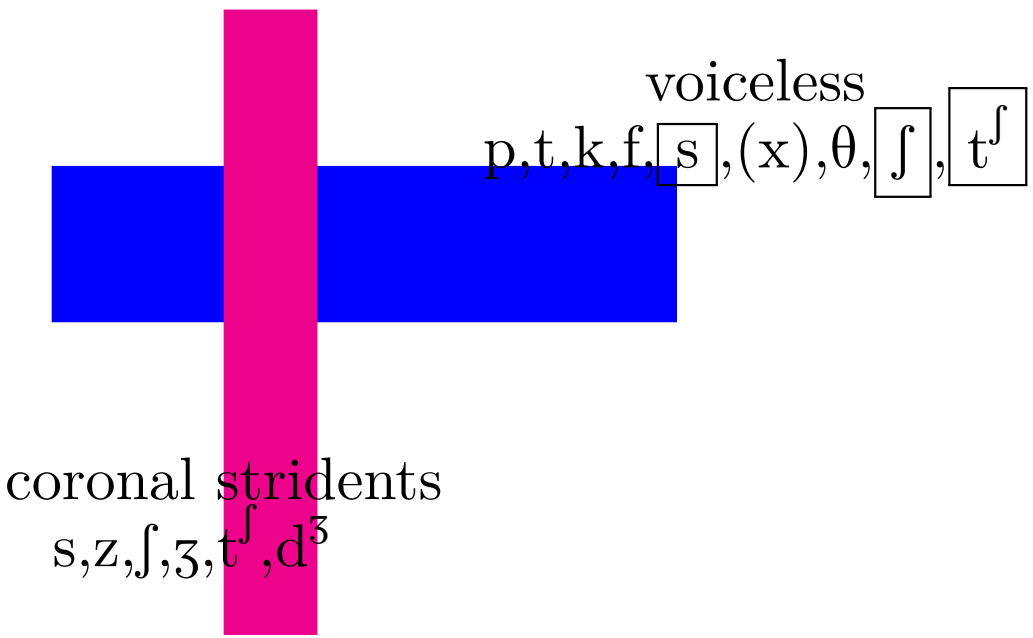
Masking in phonology 1: stimulus

- The stimulus for devoicing
- NOT a natural class
- “voiceless segments that are non-strident or non-coronal”



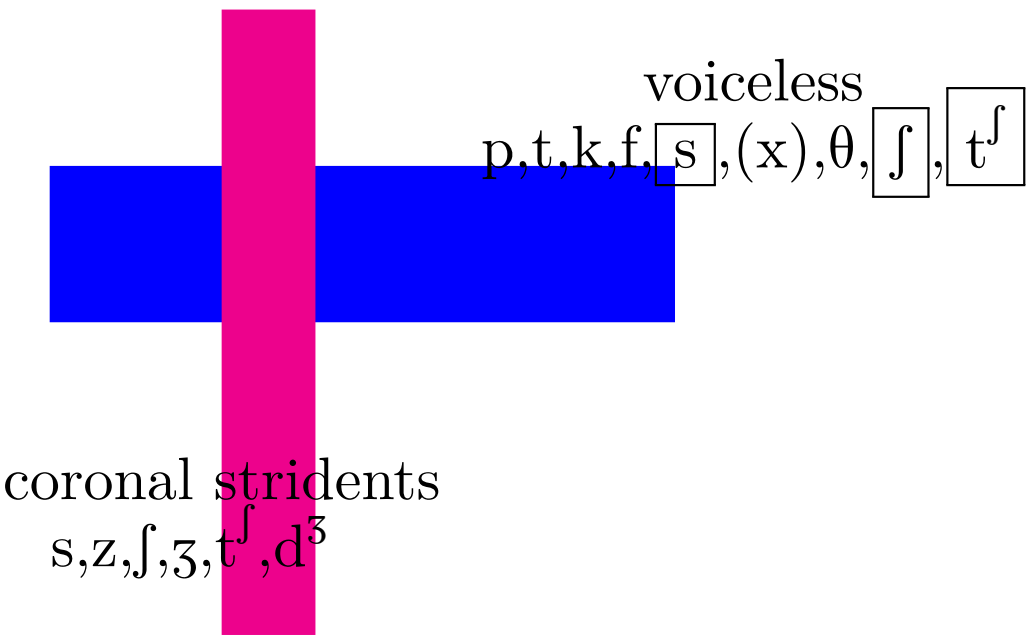
Masking in phonology 2: amodal completion

- Can't help but formulate rule (based on natural class)
- Problem of /s,ʃ,tʃ/ solved by masking, amodal completion
- *Bach*[s] with /x/ follows automatically



Masking in phonology 2: amodal completion

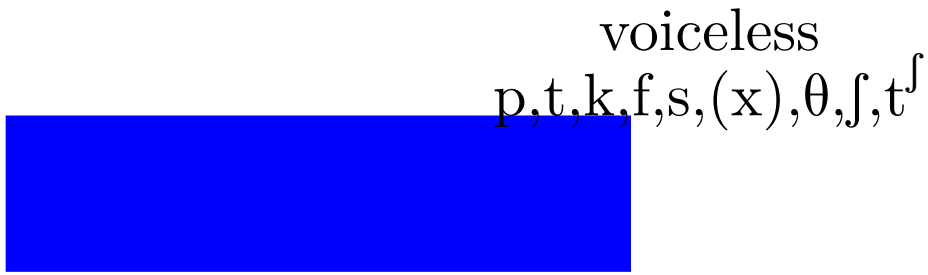
- Can't help but formulate rule (based on natural class)
- Problem of /s,ʃ,tʃ/ solved by masking, amodal completion
- *Bach*[s] with /x/ follows automatically



/s,ʃ,tʃ/ are "masked" by bleeding rule ordering

Masking in phonology 3:

- What's acquired for devoicing rule?



Despite PoS

Outline

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'
- Rule ordering obscures natural classes

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'
- Rule ordering obscures natural classes
- ∴ You can't learn features and classes from surface distributions.

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'
- Rule ordering obscures natural classes
- ∴ You can't learn features and classes from surface distributions.
  - Stimulus is not impoverished, it's downright depraved.

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'
- Rule ordering obscures natural classes
- ∴ You can't learn features and classes from surface distributions.
  - Stimulus is not impoverished, it's downright depraved.
  - But the learner is *limited / epistemically bounded* in such a way that s/he can't see that

Phonology Isn't Different

- You need a theory of grammar in order to do acquisition
- e.g. 'Rules are formulated in terms of natural classes' & 'Rules are ordered'
- Rule ordering obscures natural classes
- ∴ You can't learn features and classes from surface distributions.
  - Stimulus is not impoverished, it's downright depraved.
  - But the learner is *limited / epistemically bounded* in such a way that s/he can't see that
  - Our model makes predictions about when 'generalization' to new segments will occur (based on set theory!)

No surprises here

There's poverty of the stimulus in phonology

- The "relation between a phonemic system and the phonetic record ...is remote and complex" (Chomsky, 1964, p. 38, *Current issues in linguistic theory*).

No surprises here

There's poverty of the stimulus in phonology

- The "relation between a phonemic system and the phonetic record ...is remote and complex" (Chomsky, 1964, p. 38, *Current issues in linguistic theory*).
- As in syntax, the "essential properties underlie the surface form" (Katz and Bever, 1976, p. 12, *The fall and rise of empiricism*)

Fin

References I

Chomsky, Noam. 2009. Opening remarks and conclusion. In *Of minds and language: a dialogue with Noam Chomsky in the Basque country*, ed. Massimo Piattelli-Palmarini, Pello Salaburu, and Juan Uriagereka. Oxford: Oxford University Press.

Chomsky, Noam. 2015. *What kind of creatures are we?*. New York: Columbia University Press.

Chomsky, Noam, and Morris Halle. 1965. Some controversial questions in phonological theory. *Journal of Linguistics* 1:97–138.

Edelman, Gerald M. 2004. *Wider than the sky : the phenomenal gift of consciousness*. New Haven: Yale University Press. URL `http://www.loc.gov/catdir/toc/ecip049/2003021089.html`.

References II

Hankamer, Jorge. 1989. *Morphological parsing and the lexicon*, 392–408. Cambridge, MA, USA: MIT Press.

Jackendoff, Ray. 2007. *Language, consciousness, culture: essays on mental structure*, volume 2007. Cambridge, Mass.: MIT Press. URL `http://www.loc.gov/catdir/toc/ecip071/2006030131.html`.

Lasnik, Howard, Marcela A Depiante, and Arthur Stepanov. 2000. *Syntactic structures revisited: contemporary lectures on classic transformational theory*, volume 33 of *Current studies in linguistics*. Cambridge, Mass.: MIT Press.

Nagel, Ernest, and James R Newman. 1958. *Gödel's proof*. New York: New York University Press.

References III

Pullum, Geoffrey K., and Barbara C. Scholz. 2001. On the distinction between model-theoretic and generative-enumerative syntactic frameworks. In *Logical Aspects of Computational Linguistics*, ed. Glyn Morrill Philippe de Groot and Christian Retoré, Lecture Notes in Artificial Intelligence, 17–43. Berlin: Springer Verlag.

Reiss, Charles. 2024. The syntactician-phonologist interface. In *Festschrift for Larisa and Andrei Avram*, ed. Anca Sevcenco, Irina Stoica, Ioana Stoicescu, Mihaela Tanase-Dogaru, Alina Tigau, and Veronica Tomescu. Bucharest University Press.

Reiss, Charles, and Veno Volenec. 2024. Adopting Large Language Models as a theory of language does refute Chomsky (but not like you think). https://lingbuzz.net/lingbuzz/008543.

Logic of Neutralization

Charles Reiss

CRISSP

March 2025

Outline

1. Enhancing (our) SPE Rule system
2. Global-LR-RL application
3. Choosing the UR I: Logic of neutralization
4. *Choosing URs II: Elegance/MDL*

Outline

SPE Rules

Let SEG be the set of segment symbols. Let ENV be the set of environment symbols. Let α and β be any member of SEG. Let γ and δ be any member of ENV. (It is possible for γ to be the same as δ.) The following are possible rules.

i. $\alpha \rightarrow \beta \; / \; \_\_ \; \gamma$

ii. $\alpha \rightarrow \beta \; / \; \gamma \; \_\_$

iii. $\alpha \rightarrow \beta \; / \; \gamma \; \_\_ \; \delta$

Nothing else is a possible rule.

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab}\ \_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\ \mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\ [\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a}\ \_\_\ \mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab}\ \_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\ \mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\ [\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a}\ \_\_\ \mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab}\ \_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\ \mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\ [\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a}\ \_\_\ \mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab}\;\_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\;\mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\;[\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a}\;\_\_\;\mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab} \_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\, \mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\, [\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a} \_\_\, \mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

The following are not possible SPE rules, at least not in a system where $\textsc{seg} = \textsc{env} = \{a, b\}$.

- $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{ab}\;\_\_$
- $\mathrm{b} \rightarrow \mathrm{w} \;/\; \_\_\,\mathrm{a}$
- $\mathrm{b} \rightarrow \mathrm{a} \;/\; \_\_\,[\mathrm{nouns}]$
- $\mathrm{a} \rightarrow \;/\; \mathrm{a}\;\_\_\,\mathrm{b}$
- a$\rightarrow$ b at the end of a word
- a$\rightarrow$ b at the beginning of a word

New symbols for SPE Rules

- $\textsc{ipa} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \;/\; \text{p} \_\_ \text{q}$
  - $ptq \rightarrow pq$
- $\#, \%$ for boundary symbols
  - $\text{f} \rightarrow \text{h} \;/\; \_\_ \%$
- $\alpha, \beta \in \textsc{seg} = \textsc{ipa} \cup \{\epsilon\}$
- $\gamma, \delta \in \textsc{env} = \textsc{ipa} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \;/\; \text{p} \_\_ \text{q}$
  - $ptq \rightarrow pq$
- $\#, \%$ for boundary symbols
  - $\text{f} \rightarrow \text{h} \;/\; \_\_ \%$
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\textsc{ipa} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \;/\; \text{p} \_\_ \text{q}$
  - $ptq \rightarrow pq$
- $\#, \%$ for boundary symbols
  - $\text{f} \rightarrow \text{h} \;/\; \_\_ \%$
- $\alpha, \beta \in \textsc{seg} = \textsc{ipa} \cup \{\epsilon\}$
- $\gamma, \delta \in \textsc{env} = \textsc{ipa} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \;/\; \text{p} \_\_ \text{q}$
  - *ptq* $\rightarrow$ *pq*
- $\#, \%$ for boundary symbols
  - $\text{f} \rightarrow \text{h} \;/\; \_\_ \%$
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \ / \ \text{p} \_\_ \text{q}$
  - *ptq* $\rightarrow$ *pq*
- #, % for boundary symbols
  - $\text{f} \rightarrow \text{h} \ / \ \_\_ \%$
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \;/\; \text{p} \_\_ \text{q}$
  - $ptq \rightarrow pq$
- #, % for boundary symbols
  - $\text{f} \rightarrow \text{h} \;/\; \_\_\%$
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \ / \ \text{p} \_\_ \text{q}$
  - *ptq* $\rightarrow$ *pq*
- #, % for boundary symbols
  - f $\rightarrow$ h / __%
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

New symbols for SPE Rules

- $\text{IPA} = \{\text{s},\text{ʃ},\text{z},\text{ʒ},\text{p},\text{t},\text{k},\text{i},\text{ɪ},\text{u},\text{ʊ},\ldots\}$
- ϵ for insertion and deletion
  - $\text{t} \rightarrow \epsilon \ / \ \text{p} \_\_ \text{q}$
  - *ptq* $\rightarrow$ *pq*
- #, % for boundary symbols
  - $\text{f} \rightarrow \text{h} \ / \ \_\_\%$
- $\alpha, \beta \in \text{SEG} = \text{IPA} \cup \{\epsilon\}$
- $\gamma, \delta \in \text{ENV} = \text{IPA} \cup \{\#, \%\}$

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __ □
- (Underspecification):

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __ □
- (Underspecification):

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __ □
- (Underspecification):

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __ □
- (Underspecification):

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __ □
- (Underspecification):

Whole lotta nothing

- Empty set: $\emptyset$
- Phonologically null morphemes: $\varnothing$
- Insert and delete: ϵ
- In rule environments 1: #, %
- In rule environments 2: p __□
- (Underspecification):

The general format for (our) **SPE Rules**

Let α and β be any member of SEG. Let γ and δ be any member of ENV. (It is possible for γ to be the same as δ.) The following are possible rules.

i. $\alpha \rightarrow \beta \; / \; \_\_ \; \gamma$
ii. $\alpha \rightarrow \beta \; / \; \gamma \; \_\_$
iii. $\alpha \rightarrow \beta \; / \; \gamma \; \_\_ \; \delta$

Nothing else is a possible rule. (This restriction is a methodological strategy.)

Basic combinatorics with 99 IPA symbols

Or allowing γ and δ to be missing

- $\alpha \rightarrow \beta \ / \ \gamma \ \_\_ \ \delta$

What decisions?

- 100 choices for α and β
- 100 choices for γ and δ
- $(100)^4 = \ 100,000,000$ rules

Basic combinatorics with 99 IPA symbols

Or allowing γ and δ to be missing

- $\alpha \rightarrow \beta \ / \ \gamma \ \_\_ \ \delta$

What decisions?

- 100 choices for α and β
- 100 choices for γ and δ
- $(100)^4 = \ 100,000,000$ rules

Basic combinatorics with 99 IPA symbols

Or allowing γ and δ to be missing

- $\alpha \rightarrow \beta \ / \ \gamma \ \_\_ \ \delta$

What decisions?

- 100 choices for α and β
- 100 choices for γ and δ
- $(100)^4 = \ 100,000,000$ rules

Outline

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: s**bbbbbb**as
  - Global: saa**bbbb**as
  - L-R: saa**bbbb**as

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: sbbbbbbas
  - Global: saabbbbas
  - L-R: saabbbbas

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: s**bbbbbb**as
  - Global: saa**bbb**bas
  - L-R: saa**bb**bbas

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: s**bbb**b**b**bas
  - Global: saa**b**b**b**bas
  - L-R: saa**b**b**b**bas

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: s**bbb**b**b**bas
  - Global: saa**b**b**b**bas
  - L-R: saa**b**b**b**bas

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \; / \; \_\_ \; \mathrm{b}$
- UR: saaababas
- SR:
  - R-L: s**bbb**b**b**bas
  - Global: saa**b**b**b**bas
  - L-R: saa**b**b**b**bas

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \ / \ \mathrm{b} \ \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaabbabbs
  - Global: saaabbabbs
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \ / \ \mathrm{b} \ \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaabbabbs
  - Global: saaabbabbs
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \ / \ \mathrm{b} \ \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaab**b**ab**b**s
  - Global: saaab**b**ab**b**s
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \ / \ \mathrm{b} \ \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaab**b**ab**b**s
  - Global: saaab**b**ab**b**s
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{b} \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaab**b**ab**b**s
  - Global: saaab**b**ab**b**s
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \ / \ \mathrm{b} \ \_\_$
- UR: saaabaabas
- SR:
  - R-L: saaab**b**ab**b**s
  - Global: saaab**b**ab**b**s
  - L-R: saaabbbbbs

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aaba
  - Global: abba
  - L-R: abaa

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aaba
  - Global: abba
  - L-R: abaa

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aa**b**a
  - Global: a**bb**a
  - L-R: a**b**aa

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aa**b**a
  - Global: a**bb**a
  - L-R: a**b**aa

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aa**b**a
  - Global: a**bb**a
  - L-R: a**b**aa

Interpreting rules

Direction of application?

- Rule: $\mathrm{a} \rightarrow \mathrm{b} \;/\; \mathrm{a} \_\_ \mathrm{a}$
- UR: aaaa
- SR:
  - R-L: aa**b**a
  - Global: a**bb**a
  - L-R: a**b**aa

There are other ways

Your word processor

- b → v / a __ a
- aba → ava
- abataba → avatava
- ababa → ?
  - avava ???

There are other ways

Your word processor

- $\mathrm{b} \rightarrow \mathrm{v} \ / \ \mathrm{a} \_\_ \mathrm{a}$
- aba $\rightarrow$ ava
- abataba $\rightarrow$ avatava
- ababa $\rightarrow$?
  - avava ???

There are other ways

Your word processor

- $\mathrm{b} \rightarrow \mathrm{v} \ / \ \mathrm{a} \_\_ \mathrm{a}$
- aba $\rightarrow$ ava
- abataba $\rightarrow$ avatava
- ababa $\rightarrow$?
  - avava ???

There are other ways

Your word processor

- $\mathrm{b} \rightarrow \mathrm{v} \ / \ \mathrm{a} \_\_ \mathrm{a}$
- aba $\rightarrow$ ava
- abataba $\rightarrow$ avatava
- ababa $\rightarrow$?
  - avava ???

There are other ways

Your word processor

- $\mathrm{b} \rightarrow \mathrm{v} \ / \ \mathrm{a} \_\_ \mathrm{a}$
- aba $\rightarrow$ ava
- abataba $\rightarrow$ avatava
- ababa $\rightarrow$?
  - avava ???

This is an empirical question

We *assume* global application

- Assume uniformity
- Provide a semantics
- Note lack of precision in rule syntax

This is an empirical question

We *assume* global application

- Assume uniformity
- Provide a semantics
- Note lack of precision in rule syntax

This is an empirical question

We *assume* global application

- Assume uniformity
- Provide a semantics
- Note lack of precision in rule syntax

Interpretation of the pattern '$\alpha \rightarrow \beta$ / γ __'

If α, β, are members of $\textsc{seg}$ *and γ is a member of* $\textsc{env}$, *then $(\alpha \rightarrow \beta \ / \ \gamma \ \_\_)^M$ is the function f (a member of F) that maps any (finite) string of mental representations $x_1 x_2 \ldots x_n$ to the string of mental representations $y_1 y_2 \ldots y_n$ such that for each index i that is greater than or equal to 1 and less than or equal to n ($1 \leq i \leq n$)...*

(a) *If $x_i = \alpha^M$ and $x_{(i-1)} = \gamma^M$, then $y_i = \beta^M$.*

(b) *Otherwise $y_i = x_i$.*

Insertion and deletion complicate things a lot.

Interpretation of the pattern '$\alpha \rightarrow \beta$ / γ ___'

If α, β, are members of SEG *and γ is a member of* ENV*, then $(\alpha \rightarrow \beta \ / \ \gamma \ \_\_\_)^M$ is the function f (a member of F) that maps any (finite) string of mental representations $x_1 x_2 \ldots x_n$ to the string of mental representations $y_1 y_2 \ldots y_n$ such that for each index i that is greater than or equal to 1 and less than or equal to n ($1 \leq i \leq n$)...*

(a) *If $x_i = \alpha^M$ and $x_{(i-1)} = \gamma^M$, then $y_i = \beta^M$.*

(b) *Otherwise $y_i = x_i$.*

Insertion and deletion complicate things a lot.

Outline

Language 1

	Form	Meaning
a.	naču	a dog
b.	načі	the dog
c.	naku	a hat
d.	načі	the hat
e.	padu	a foot
f.	padi	the foot

- There seems to be a difference in the lexicon between /k/ and /č/, given the 'minimal pair' *naču, naku*
- The difference appears to be **neutralized** in some environments
  - alternation
  - distribution

- There seems to be a difference in the lexicon between /k/ and /č/, given the 'minimal pair' *naču, naku*
- The difference appears to be **neutralized** in some environments
  - alternation
  - distribution

- There seems to be a difference in the lexicon between /k/ and /č/, given the 'minimal pair' *naču, naku*
- The difference appears to be **neutralized** in some environments
  - alternation
  - distribution

- There seems to be a difference in the lexicon between /k/ and /č/, given the 'minimal pair' *naču, naku*
- The difference appears to be **neutralized** in some environments
  - alternation
  - distribution

How do we choose?

- ‘hat’ is /nak/
  - and rule is k → č / ___ i

OR

- ‘hat’ is /nač/
  - and rule is č → k / ___ u

How do we choose?

- ‘hat’ is /nak/
  - and rule is $\mathrm{k} \rightarrow \check{\mathrm{c}} \; / \; \_\_\_ \; \mathrm{i}$

OR

- ‘hat’ is /nač/
  - and rule is $\check{\mathrm{c}} \rightarrow \mathrm{k} \; / \; \_\_\_ \; \mathrm{u}$

How do we choose?

- ‘hat’ is /nak/
  - and rule is $\mathrm{k} \rightarrow \check{\mathrm{c}}$ / ___ i

OR

- ‘hat’ is /nač/
  - and rule is $\check{\mathrm{c}} \rightarrow \mathrm{k}$ / ___ u

How do we choose?

- ‘hat’ is /nak/
  - and rule is $\mathrm{k} \rightarrow \check{\mathrm{c}}$ / ___ i

  OR
- ‘hat’ is /nač/
  - and rule is $\check{\mathrm{c}} \rightarrow \mathrm{k}$ / ___ u

How do we choose?

- ‘hat’ is /nak/
  - and rule is $\mathrm{k} \rightarrow \mathrm{\check{c}} \; / \; \_\_\_ \; \mathrm{i}$

OR

- ‘hat’ is /nač/
  - and rule is $\mathrm{\check{c}} \rightarrow \mathrm{k} \; / \; \_\_\_ \; \mathrm{u}$

"One meaning—one form" but *which* form?

How do we choose the lexical form?

The cognitive science approach

- "we" the linguists
- "we" the humans

Informal version of reasoning:

The lexical form for 'dog' is /nač/. The lexical form for 'hat' is either /nak/ or /nač/. But it can't be /nač/ since the lexical form for 'dog' is /nač/ and the two forms behave differently—one shows up as [nač] with the indefinite suffix, the other as [nak]. So the lexical form for 'hat' must be /nak/.

What is our method of reasoning?

- premises/assumptions—these can fail/get replaced
- rules of inference/logic—these cannot fail

Non-alternation Assumption–NAA

If there is one surface form of a morpheme in all environments, then the phonological representation of the lexical item is identical to that form.

Language 1

	Form	Meaning
a.	naču	a dog
b.	načі	the dog
c.	naku	a hat
d.	načі	the hat
e.	padu	a foot
f.	padi	the foot

Surfacing lexical form assumption—SLFA

If there is more than one surface form, then the phonological representation of the lexical item is identical to one of those forms.

NAA is just a special case of SLFA. This is apparent when we rephrase SLFA thus:

The lexical form surfaces.

But we'll continue to treat NAA and SLFA separately for expository purposes.

- It should be noted that neither of these assumptions are a logical necessity
- Later, we will find that we have to give them up ☹

- NAA does a lot of work for us
- SLFA tells us that UR of ‘hat’ is nak- or nač-

- NAA does a lot of work for us
- SLFA tells us that UR of ‘hat’ is nak- or nač-

How can we decide on UR for 'hat'?

	Form	Meaning
a.	naču	a dog
b.	načі	the dog
c.	naku	a hat
d.	načі	the hat
e.	padu	a foot
f.	padi	the foot

Modus Tollendo Ponens (MTP)

For any two propositions p and q, if (p or q) is true and p is false, then it can be concluded that q is true.

- It is true that either John is fast or Mary is strong.
- It is not true that John is fast.
- Therefore, it is true that Mary is strong.

[Note that (p or q) = (q or p). Order does not matter.]

Modus Tollendo Ponens (MTP)

For any two propositions p and q, if (p or q) is true and p is false, then it can be concluded that q is true.

- It is true that either John is fast or Mary is strong.
- It is not true that John is fast.
- Therefore, it is true that Mary is strong.

[Note that (p or q) = (q or p). Order does not matter.]

Modus Tollendo Ponens (MTP)

For any two propositions p and q, if (p or q) is true and p is false, then it can be concluded that q is true.

- It is true that either John is fast or Mary is strong.
- It is not true that John is fast.
- Therefore, it is true that Mary is strong.

[Note that (p or q) = (q or p). Order does not matter.]

Modus Tollendo Ponens (MTP)

For any two propositions p and q, if (p or q) is true and p is false, then it can be concluded that q is true.

- It is true that either John is fast or Mary is strong.
- It is not true that John is fast.
- Therefore, it is true that Mary is strong.

[Note that (p or q) = (q or p). Order does not matter.]

Modus Tollendo Ponens (MTP)

For any two propositions p and q, if (p or q) is true and p is false, then it can be concluded that q is true.

- It is true that either John is fast or Mary is strong.
- It is not true that John is fast.
- Therefore, it is true that Mary is strong.

[Note that (p or q) = (q or p). Order does not matter.]

Let's apply our reasoning to Language 1

	Form	Meaning
a.	naču	a dog
b.	načі	the dog
c.	naku	a hat
d.	načі	the hat
e.	padu	a foot
f.	padi	the foot

Premise 1 Either the phonological form of the morpheme meaning 'hat' is /nač/ or it is /nak/.

	Form	Meaning
a.	naču	a dog
b.	načі	the dog
c.	naku	a hat
d.	načі	the hat
e.	padu	a foot
f.	padi	the foot

Premise 1 Either the phonological form of the morpheme meaning 'hat' is /nač/ or it is /nak/.

By SLFA

Reductio Ad Absurdum (RAA)

For any proposition p, if it is assumed that p is true and it can be demonstrated that with that assumption a contradiction can be reached, then it can be concluded that p is false.

Let's assume that the lexical form of 'hat' is /nač/

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning ‘hat,’ we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: č → k / ___ u
- NAA tells us that the lexical form of ‘dog’ is /nač/
- If the grammar has R_1, then the form meaning ‘a dog’ should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of ‘hat’ must have been wrong.
- MTP: Since the UR of ‘hat’ is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: k → č / ___ i

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: č → k / ___ u
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: k → č / ___ i

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{\mathrm{c}} \rightarrow \mathrm{k}$ / ___ u
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $\mathrm{k} \rightarrow \check{\mathrm{c}}$ / ___ i

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{\mathrm{c}} \rightarrow \mathrm{k}$ / ___ u
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $\mathrm{k} \rightarrow \check{\mathrm{c}}$ / ___ i

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{c} \rightarrow k \; / \; \_\_\_ \; u$
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $k \rightarrow \check{c} \; / \; \_\_\_ \; i$

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{\mathrm{c}} \rightarrow \mathrm{k} \; / \; \_\_\_ \; \mathrm{u}$
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $\mathrm{k} \rightarrow \check{\mathrm{c}} \; / \; \_\_\_ \; \mathrm{i}$

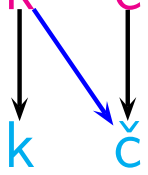
- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{c} \rightarrow k \; / \; \_\_\_ \; u$
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $k \rightarrow \check{c} \; / \; \_\_\_ \; i$

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{\mathrm{c}} \rightarrow \mathrm{k}$ / ___ u
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $\mathrm{k} \rightarrow \check{\mathrm{c}}$ / ___ i

- Since /nač/ is (by assumption) the underlying phonological representation of the morpheme meaning 'hat,' we need the phonology to generate the alternant [nak].
- In other words, we need a rule that turns *č* into *k* when it occurs before the *u*
  - R_1: $\check{c} \rightarrow k \; / \; \_\_\_ \; u$
- NAA tells us that the lexical form of 'dog' is /nač/
- If the grammar has R_1, then the form meaning 'a dog' should come out as [naku], but it does not
- RAA: This contradiction tells us that our assumption about the UR of 'hat' must have been wrong.
- MTP: Since the UR of 'hat' is either /nak/ or /nač/, and it is not /nač/, it must be /nak/
- So, the grammar must have a rule like this:
  - R_2: $k \rightarrow \check{c} \; / \; \_\_\_ \; i$

Relations between UR and SR of segments

Segment mapping diagram (SMD):



Underlying segs (present in lexicon, selected by MORPHOLOGY)

Surface segs that show effects of the PHONOLOGY

Outline

An alternation

form	gloss
naku	a hat
nači	the hat

How do we find the UR?

- We have a single underlying segment x that surfaces as either [k] or [č].
- Let's assume that x will be identical in form to either [k] or [č].
- How do we choose which one? What is the identity of x?

How do we find the UR?

- We have a single underlying segment x that surfaces as either [k] or [č].
- Let's assume that x will be identical in form to either [k] or [č].
- How do we choose which one? What is the identity of x?

How do we find the UR?

- We have a single underlying segment x that surfaces as either [k] or [č].
- Let's assume that x will be identical in form to either [k] or [č].
- How do we choose which one? What is the identity of x?

Same language

Some more data

form	gloss
nak	a hat
načі	the hat
naka	hats

Disjunctive rule

č → k / ___% or a

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

- That is, we need to turn /č/ into [k] if it occurs at the end of the word or before [a].
- *SPE* does not allow for the use of disjunctive conditions, those that make use of the notion OR
- So, we assume that such a rule is not possible.
- Claim is *not* that we know that this is not the correct rule for the language in question.
- Claim is that *given the restricted model of rules we proposed*, it is impossible to state the disjunctive rule.
- The idea is to maintain the restricted model of rules if possible—basic scientific methodology.

Alternative

Separate rules

- č $\rightarrow$ k / ___% AND
- č $\rightarrow$ k / ___a

Single rule: A more elegant solution

$$k \rightarrow č \; / \; \_\_i$$

Justification

- This analysis works and it does not force us to posit two separate rules or to add to the set of primitive notions allowed in our rule conditions.
- This suggests that this analysis is more elegant than the alternatives we considered, where we were forced to enrich our set of primitives used in conditions or to use multiple rules.
- The single rule analysis captures a real generalization—we get [č] only before [i], and we get [k] elsewhere, wherever the input string does not match the rule statement.

Single rule: A more elegant solution

k → č / __i

Justification

- This analysis works and it does not force us to posit two separate rules or to add to the set of primitive notions allowed in our rule conditions.
- This suggests that this analysis is more elegant than the alternatives we considered, where we were forced to enrich our set of primitives used in conditions or to use multiple rules.
- The single rule analysis captures a real generalization—we get [č] only before [i], and we get [k] elsewhere, wherever the input string does not match the rule statement.

Single rule: A more elegant solution

k → č / ___i

Justification

- This analysis works and it does not force us to posit two separate rules or to add to the set of primitive notions allowed in our rule conditions.
- This suggests that this analysis is more elegant than the alternatives we considered, where we were forced to enrich our set of primitives used in conditions or to use multiple rules.
- The single rule analysis captures a real generalization—we get [č] only before [i], and we get [k] elsewhere, wherever the input string does not match the rule statement.

Single rule: A more elegant solution

k → č / ___i

Justification

- This analysis works and it does not force us to posit two separate rules or to add to the set of primitive notions allowed in our rule conditions.
- This suggests that this analysis is more elegant than the alternatives we considered, where we were forced to enrich our set of primitives used in conditions or to use multiple rules.
- The single rule analysis captures a real generalization—we get [č] only before [i], and we get [k] elsewhere, wherever the input string does not match the rule statement.

This reasoning becomes very important when we use features to decompose segments into NATURAL CLASSES such as "nasal consonants"

CRISSP: Neutralization Practice

(1)

	form	gloss
a.	nɔʎ	ox
b.	nɔʎi	oxen
c.	nɔɾ	sheep
d.	nɔʎi	sheep (pl.)

- List all morpheme alternants
  - 'ox':
  - 'sheep':
  - sg.:
  - pl.:
- Choose an underlying lexical representation for each morpheme:
  - 'ox':
  - 'sheep':
  - sg.:
  - pl.:
- Posit a phonological rule:

Now give a Underlying Representation for each word and show how it is derived by the rule. Remember that a given meaning has only one form in all URs. So the morpheme for 'sheep' should be the same in the UR for 'sheep' and 'sheep (pl.)'.

Underlying Rep				
Effect of Rule				
Surface Rep	'ox'	'oxen'	'sheep–SG'	'sheep–PL'

Provide the same kind of analysis (in the same format) for the rest of these languages:

(2)

	form	gloss
a.	hɔva	ox
b.	hɔvi	oxen
c.	hɔba	sheep
d.	hɔvi	sheep (pl.)

(3)

	form	gloss
a.	hɔba	ox
b.	hɔvi	oxen
c.	hɔba	sheep
d.	hɔbi	sheep (pl.)

(4)

	form	gloss
a.	vɛʁ	ox
b.	vɛθon	oxen
c.	vɛʁ	sheep
d.	vɛʁon	sheep (pl.)

(5)

	form	gloss
a.	vɛʁ	ox
b.	vɛθon	oxen
c.	vɛθ	sheep
d.	vɛθon	sheep (pl.)

(6)

	form	gloss
a.	to	ox
b.	tori	oxen
c.	tor	sheep
d.	tori	sheep (pl.)

(7)

	form	gloss
a.	tʊn	ox
b.	tʊma	oxen
c.	tʊn	sheep
d.	tʊna	sheep (pl.)

(8)

	form	gloss
a.	tən	ox
b.	təma	oxen
c.	təm	sheep
d.	təma	sheep (pl.)

(9)

	form	gloss
a.	ba	ox
b.	balku	oxen
c.	ba	sheep
d.	baku	sheep (pl.)

(10) This problem requires you to expand on what a rule environment allows. Explain what you need to do as part of your solution.

	form	gloss
a.	vɛθ	ox
b.	vɪθon	oxen
c.	vɛθ	sheep
d.	vɛθon	sheep (pl.)